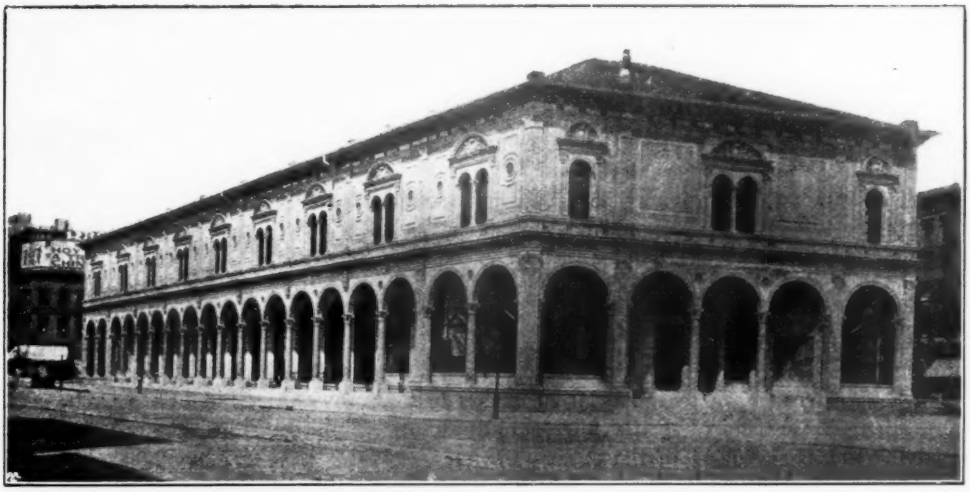

Terra-cotta building, New York [McKim, Mead & White, architects].

# AMERICAN METHODS OF ERECTING BUILDINGS.

By R. A. Denell,

MANAGING DIRECTOR OF THE WARING WHITE BUILDING COMPANY, LTD.

**Read before the Royal Institute of British Architects, Monday, 20th November 1905.**

THE receipt of a letter from your Secretary asking me to read a paper on "American Methods of Erecting Buildings" before the Institute gave me extreme pleasure, and yet, at the same time, anxiety—pleasure because I certainly deemed it a great honour, and anxiety as to whether I should be able to write a paper which would be interesting enough to take up the valuable time of the members of this world-renowned body.

I presume that by "American methods" is meant the methods of the United States, or, as Sir Edward Clarke, K.C., has so aptly put it, U.S.O.N.A.; for, although Canadian are practically the same as American methods, this cannot be said for Mexico or the different States in Central and South America.

I must say I often get tired of hearing of American methods, and especially to be expected to sustain their reputation for strenuousness; for wherein can they be said to be different from English methods if we omit the so-called sky-scraper, a building which is practically the result of the evolution of modern business? Hotels, stores, &c., can be, and are, analogous to office buildings in construction; but as regards domestic, public, church, and factory work &c., there is really no great difference except that of detail—a difference which applies equally to all countries, and less so between England and America than others.

The principles of architecture and the materials of construction are much the same to-day as they were in the past, and we can therefore hardly expect startling changes. Whatever differences there are, result from the evolutionary change of living, which the modern architect and builder alike have to meet, just as formerly. In olden times the architect was artist, engineer, and craftsman, in fact everything except the client, who was generally the Church or the Government; and in those days thirty years in which to

complete a work was considered quite fast enough. Nowadays the client in most cases desires to give the commission to the architect to-day and to have the work completed next week, so that he may enjoy the revenue during his own lifetime rather than leave the enjoyment of it to posterity.

Increase of rapidity of construction and economy are the dominant factors in the consideration of the present subject.

The title of this paper may be considered to apply broadly to constructive methods, or more narrowly to the management of a contractor's business. If I took the latter view I should have practically nothing to say. American contractors are generally good business men, and apply business principles to their affairs. They try to make every man in their employ responsible in his own position or sphere, advancing him when he shows capabilities to trust his own judgment and to go ahead alone successfully. In this they are no different, of course, from large contractors the world over. The best builders in America, as a general rule, have served a large portion of their apprenticeship in architects' offices, and this has resulted in a better understanding of the architects' ideals and demands, thus enabling them to assist rather than hamper.

Labour to the contractor is of primary importance. Much has been written about the British working man, but I must say that I do not agree with the writers of the articles I have read. They all attack the bricklayer. Now, gentlemen, I think the English bricklayer does better work than his fellow in any other country. As regards the amount of work done, I have had men in this country who laid an equal and in many cases a larger number of bricks per day, under similar conditions, than I have had in America. Continental brickwork does not compare with work here. I consider, too, both the English stonemason and the navvy splendid workmen.

When it is remembered that the wages of building mechanics in America range from 1*s.* 10½*d.* to 2*s.* 11*d.* per hour for an eight hour day, while the labourer gets from 1*s.* to 1*s.* 6*d.* per hour, you feel that one ought always to get good men; but unfortunately you do not. The main difference, then, I consider is that here we get careless of our labour by reason of its cheapness. If it were more expensive we should watch over it more and give it better supervision. I believe it is a rule among the best American contractors never to allow more than twenty-five men to work without a foreman, the result being that he sees that they work, and, what is more important, that the work is planned out for them in advance, and that their materials will be ready as wanted. I mention this last particularly because I have noticed so often that a man will waste hours waiting for materials, and also is disposed to put his hands in his pockets and contemplate what there is to do next, and how he shall do it, when, in my opinion, this ought not to be his to do, but he should simply be required to do his work as instructed quickly and well.

One of the chief reasons for the rapidity of construction in large buildings in America is, I believe, the way with which materials are dealt. Contractors in America do not have their own shops. Yards for the storage of plant &c. of course they must have. Time being an essential factor, it would be impossible for a contractor there to execute joinery, stonework, marble-work, and ornamental plastering so efficiently or so well with his own plant and in his own shops as each man in his own particular trade who has made it a speciality and has had life-long experience in it. Steel, terra-cotta, partitions, and mechanical plant are manufactured by much larger firms than here, and can therefore be supplied much more quickly. The builder stands, however, between the architect and the specialists, seeing that the material is correct in quality and workmanship, and that it is being worked carefully to details, and also that it is being advanced so as to be ready at the proper time to fit in with the other work.

There are certain slight differences as regards plant—cranes, scaffolding, and hoists—of which I show examples [figs. 1 and 2]. With the exception of those used in "sky-scraper" construction, the cranes in this country are as practical as those used in America; while as to hoists, when cranes are used there should be very little difference as regards efficiency between them and hoists. When, however, the handling of materials is performed by means of baskets, hods, &c., I consider it childish (except of course under special conditions).

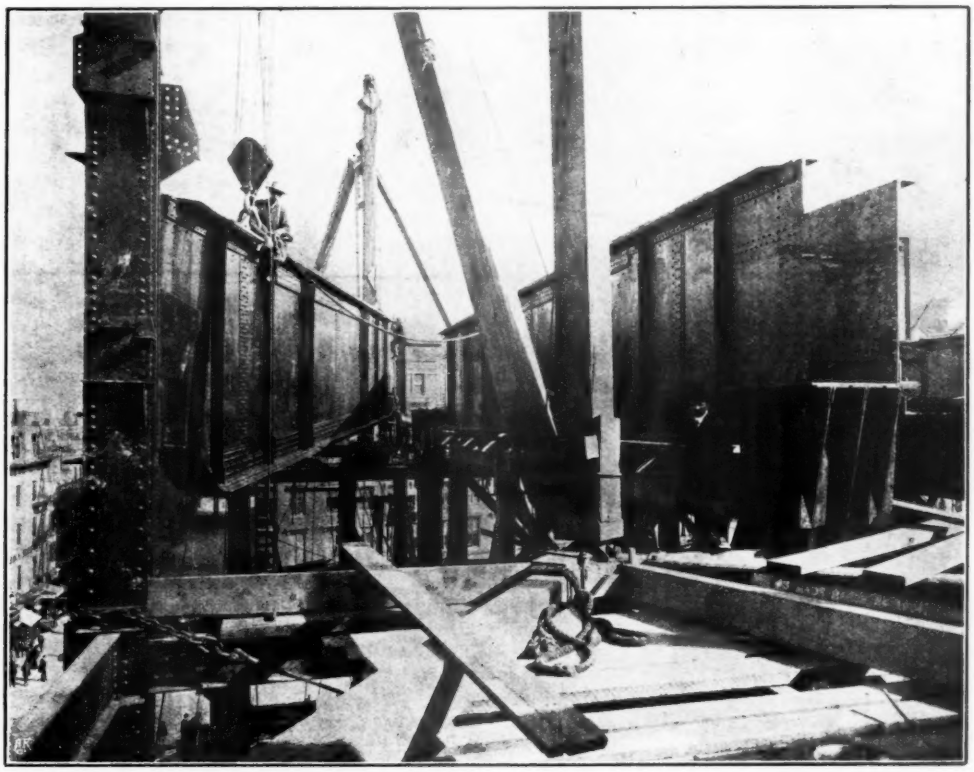

FIG. 1.—AMERICAN CRANE.

But coming to the larger aspect of the subject, the difference in the methods of construction in American practice is the result of evolution in response to certain conditions, climatic and economic, and also in response to public demand.

I do not propose to deal with the erection of domestic buildings and other small work in provincial towns and villages, because the construction and method of erection are virtually the same as in this country, the contractors being small men, or separate tradesmen being employed.

Disregarding public work, which is somewhat an exception, and dealt with in much the same way as here, the client of the American architect may be stated to be either a successful practical man who has arrived at his position by his own efforts, or, as is very seldom the case (especially outside the Eastern cities), a man of inherited wealth. Therefore, as the

predominating client is practical and commercial, his demands are those that result in the greatest financial benefit to himself, such as speed, economy in construction, greatest available space to let, &c.

The remuneration of American architects is the same as here; but for this much more work is required, more detail drawings having to be furnished, and no assistance being afforded from clerks of works or quantity surveyors; while the foremost architects, in order to succeed, have to keep a large and competent staff of engineers. The result of this is that the successful architect's time is taken up in business matters and in criticising the work of his designing staff, leaving him no time to use the pencil himself, the only exception to this being in the case of a partnership where the work is allocated to the various members of the firm.

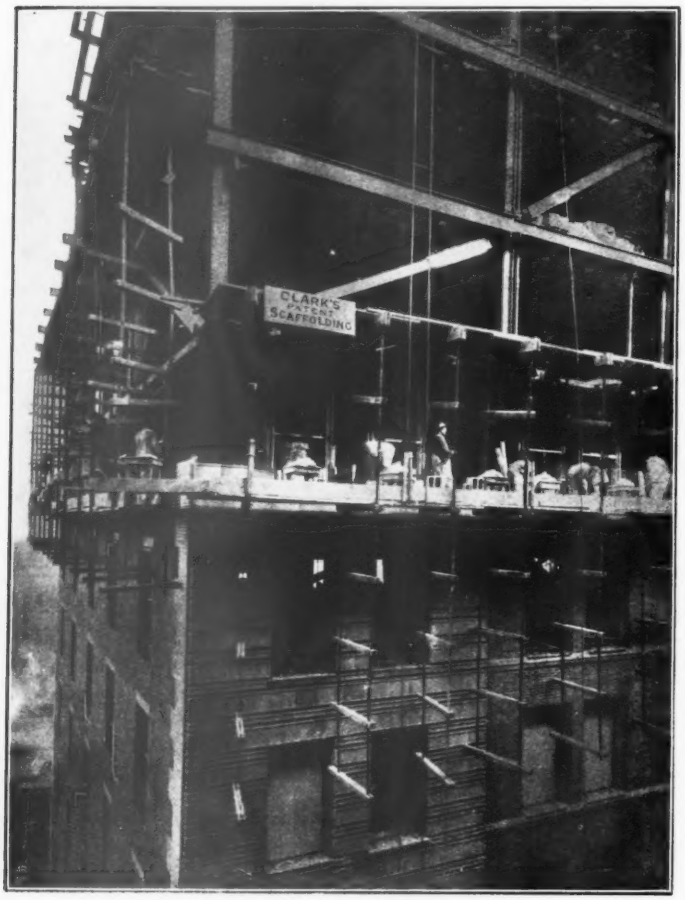


FIG. 2.—SCAFFOLDING.

It may be mentioned that in America the quantity surveyor is unknown. The time given builders in which to estimate is rarely more than a fortnight from the time the plans and specifications are furnished to them, and each builder keeps his own staff of estimators, as they are called, who take off the quantities from the architect's plans and specifications. This results in a saving of time.

As regards the clerk of works, American practice is essentially the same as English, only the architect's representative is called "superintendent." He is paid by the architect and works under his instructions.

If consulting mechanical, sanitary, and structural steel engineers are required, they are generally employed by the architect; and to avoid the expense of this is the main reason why so many architects have these engineers on their office staff. I might point out that this would only be remunerative when a large amount of work was done annually. This in the cases of men who deal with the largest work amounts to from one to four millions sterling per annum, and in the latter cases an architect's establishment costs would be about £50,000 a year. With this

staff an architect can from the beginning furnish a contractor with full information, both scale and detail drawings; and I must say that this is one of the most necessary things for a builder or an architect who desires speed in construction. This, I am sure, is a primary essential to speed, allowing the builder immediately on signing the conditions of contract to arrange for his steel and other materials to be manufactured in advance, and assembled elsewhere than on the site.

The largest builders have a competent staff of mechanical, sanitary, and structural steel engineers who draw up their own plans and specifications, of course working in harmony with the architect, and submit their tenders for these branches of work from their own plans, thus saving the architect from all this increased establishment expenditure and attendant worries. In such cases the contractor guarantees the work as to quality and efficiency. With the engineering staff in his own employ, a builder can subdivide the engineering work, so that he can buy the parts from the best makers and then assemble them—which works out cheaper as it saves the intermediate profits.

As nearly all the largest buildings have their own mechanical plant which heats, lights, furnishes power for lifts, pumping water, &c., it can readily be seen that if the architect does it all efficiently he must neglect the plan and designing of the building, unless, as before mentioned, he has a special trained staff of engineers to do this work for him, which is only done in a few of the largest architects' offices.

The Building Laws here undoubtedly restrain the contractor and architect as to speed. Different surveyors have also to be dealt with, whereas in America each city has its own building department, which is the only authority to be consulted. This means that before starting work plans must be filed and approved, after which, except for variations &c., one can proceed without further interference when following plans which have been filed. The larger cities now have a competent staff to deal with building works; and an engineering staff to calculate the strength of the various parts from the drawings, so as to see that they conform to the By-laws, and are structurally safe, thus preventing "jerry"-building &c.

Again, each city has its land surveyors, who at once, upon notification, fix according to law, and to deed and title, the exact boundaries of your client's property. Thus, the architect, immediately upon starting his work, obtains exact dimensions for his plans, so that the builder has these fixed dimensions to work to, and from which to order materials in advance. It will be appreciated what a great advantage this is to the builder, as he then has no hesitation in ordering his materials ahead, so that he may have them ready when needed. You will notice how all American working drawings have figured dimensions, these not being left to be scaled, as is generally the case in this country. I might say here that one of the best builders in America once told me that erecting a building was nothing but putting an experienced and energetic man in charge and seeing that he was furnished with materials to work with, without any worry or trouble upon his part. I would also point out that with the small cubical contents of buildings allowed by the Acts, it is impossible to store or stack materials on the work as in America; and this compels English builders to live more or less from hand to mouth, relying on their carters or their own teams for supplies. I have found this to be the cause of very frequent stoppages and delays.

As to American materials allow me to give you a hasty comparison, explaining wherein they are different from those used here.

A small brick is used, measuring on the average about $8\frac{1}{4}$ inches by $4\frac{3}{8}$ inches by $2\frac{3}{8}$ inches, except glazed bricks, for which the English size is generally used. There are no other essential differences in bricks except the natural ones in clays, due to the different localities, a greater range of colour and texture being found in facing bricks, which gives architects much

greater scope for colour schemes. Facing bricks of a great many special sizes are also used, such as the "Norman," which is a brick measuring 12 inches by $4\frac{1}{4}$ inches by 3 inches, or the "Roman," which measures 12 inches by $4\frac{1}{4}$ inches by $1\frac{1}{2}$ inch. In America the bricks are laid in all manner of bonds, such as English, Flemish, no-bond, &c. For this last reason English brickwork is superior structurally to American.

FIG. 3.—STEEL-FRAME BUILDING, WITH TERRA-COTTA COVERING.

The United States at the present time manufactures practically all its own cement, and it is very good, though not, as a whole, equal to English Portland.

Lime is very much the same, except that on the average it is whiter in the United States than here.

Timber, of course, is much more extensively used. It is sold by board measure, namely, so much per thousand feet of 1 inch by 12 inches by 12 inches. It is much cheaper, and this is the reason so many wooden houses are erected, and why so much "mill construction," or what is called slow burning construction, is adopted. The principle of this latter is to use large timbers throughout, *i.e.* heavy joists measuring at least 3 inches by 12 inches, and stanchions or pillars at least 12 inches by 12 inches; while all flooring is 3 inches thick or more, so that in case of fire the timbers will char for a long time before breaking. This system of construction is recognised by insurance companies as second only to the fire-resisting construction, and when a sprinkler system is installed is considered, in the majority of cases, equally as good.

In stones there is a greater variety, both in quality and colour. The favourite, as here, is a white limestone, which comes from the State of Indiana, and is almost identical with Portland, except that it has no shells in its structure. The American dark granites—blue, black, and red—are not as fine as Scottish granites, but in white and grey granites there is a much greater variety. Local marbles have a greater range than English and Irish, and are superior to many Belgian and French marbles, though not so beautiful as the Grecian. All the finest Government work is in granite or marble. The cost of stonework in the States averages

about the same as here, and granite is a little cheaper. The stone there is finely worked, and the surface is generally tooled. This is called drove work, and is done by machinery: it consists of about eight cuts, *i.e.* fine channels, to the inch, and has the effect of making the work look very true and straight, as the surface does not reflect light in the way that a smooth or polished surface does, such as, for example, a sheet of window glass.

Terra-cotta in my opinion has reached a higher usefulness in America than here, the reasons for this being, first, the greater variety of clays, which gives the opportunity of furnish-

FIG. 4.—IRON STAIRCASE, UNION PASSENGER STATION, OMAHA, NEB. (WALKER & KIMBALL, ARCHITECTS).

ing almost any colour or shade an architect may desire for polychromatic effect; and secondly, that terra-cotta is particularly suited for an external covering to a steel skeleton frame [fig. 3]. I believe America is also in advance in its manufacture, as the terra-cotta is straighter, truer, and, what is of still greater importance to the architect, produced in much larger blocks than here, thus more nearly approaching stone in effect. A great deal of glazed terra-cotta or faïence, or what is called in England "Carrara-ware," is used in America, as clients call commercially for buildings easily kept clean and bright in smoky and dirty cities—and practically all the larger cities in the Middle West come within this category.

Metals are practically the same as in this country. I will deal with steel construction later. I would, however, call attention to their so-called ornamental iron and bronze work [fig. 4]. This is very extensively used, principally resulting from its demand in fire-resisting buildings, and includes a much greater variety of cast work than here, all staircases &c. being built of ornamented cast iron.

There is very little concrete stair work in the States, cast iron being used in fire-resisting buildings on account of the lightness of construction. The cast-iron staircases have iron stringers and risers, with marble treads. In buildings where several stories are exactly alike one pattern only is needed, and the cast-iron stringers can be attached directly to the steel frame of the building. In buildings not fire-resisting cast-iron stair work is replaced by wood. It would, in my opinion, be better in American practice, especially as regards fire-resistance, to follow English practice by using concrete staircases in all non-fire-resisting buildings, and also as regards the system of concrete lintels in use here, but not there.

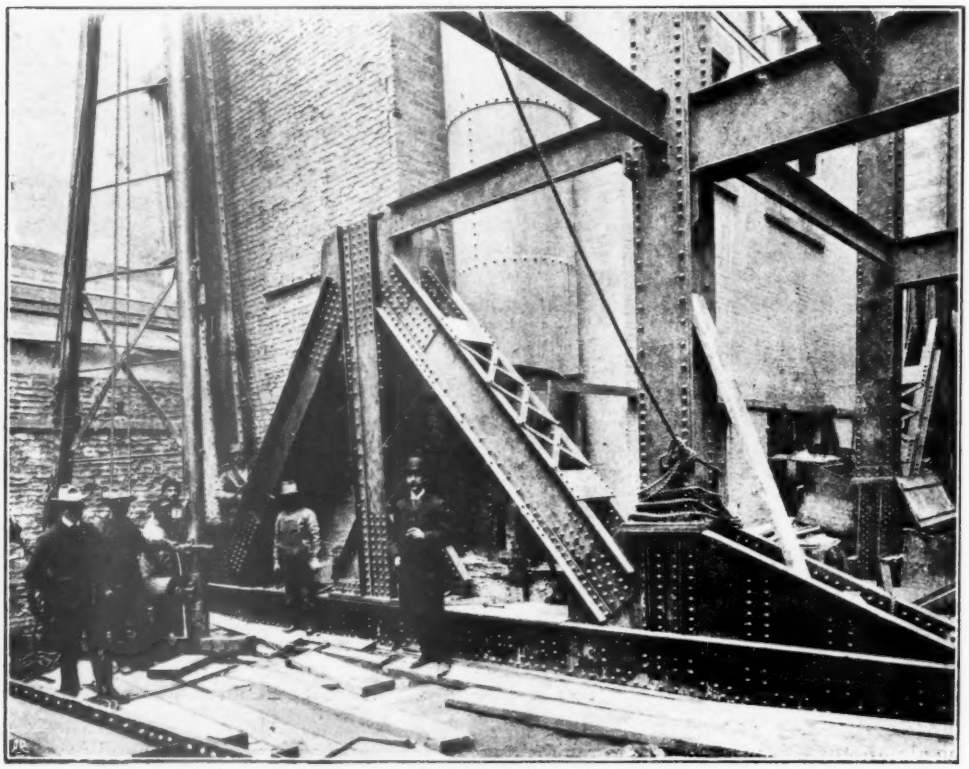

FIG. 5.—CANTILEVER FOUNDATION.

As regards floor construction and partitions, nearly all buildings not exceeding eight stories in height are not fire-resisting, which I am glad to see is not the case here. In such buildings the floors and partitions are nearly all of timber construction. For buildings over eight stories in height the prevailing system of floor construction is either hollow terra-cotta blocks built in arch form, with either flat or segmental soffits as an architect may desire, or some form of reinforced concrete. A hollow-floor construction is a great advantage, as it is lighter, thus materially saving in the amount of steel required in a building. I would here remark that if architects would allow greater depth for floors considerable saving in weight of steel could be effected. A hollow floor can be designed with a total weight of all steel in it of 6 lb. per square foot, whereas the solid construction requires on an average about 15 lb.

per square foot. The double floor has also other advantages, such as soundproofness and increased rigidity, thus militating against vibration and deflection. The solid concrete floor with light joists placed closely together is never used in America. Partitions in these buildings are of hollow terra-cotta blocks, expanded metal, or "Mack." Breeze building blocks are not yet used. In New York all buildings over twelve stories in height must not only have all floors and partitions of fire-resisting material, but if woodwork is used it must be treated, whatever its kind, by a fire-resisting process. All exterior window frames and sashes must be of metal with fire-resisting glazing.

As for foundations—their design, of course, depends upon the locality, *i.e.* the soil. Where the soil is of a ballast nature the foundations are generally of the grillage type—steel joists and concrete. In New York, which practically stands on rock, although in some cases at a considerable depth, concrete piers are used, these in the deepest cases being sunk by means of pneumatic caissons. In Chicago, where the problem has been most difficult, the methods of constructing foundations have developed along with the progress in steel-frame construction; that is to say, piers of granite, stone, or brick, gradually spreading until of the necessary area, were first adopted. Then the floating foundation was tried: this is simply steel grillage and concrete, each pier being entirely separate and calculated to sustain a maximum load of 3,750 lb. per square foot. This did not prove perfectly satisfactory, as, owing to the

FIG. 6.—GILLENDER BUILDING, NEW YORK.

compression of the soft clay, considerable settlement took place. Then wooden piles were tried; but it is thought a stable foundation for a high building has been found at last for this soil. It was discovered by boring for wells that there was rock about 100 feet down. What are virtually concrete piers 100 feet deep, and from 5 feet to 7 feet 6 inches in diameter, are therefore being constructed, and the bases of the steel stanchions put on these piers, the weight thus practically being sustained by the rock. The method of constructing these has been so improved that they work out at an average cost of about £200 each. One interesting development in regard to foundations in America, and one of the novelties that have there arisen, is the cantilever foundation [fig. 5]. Party-walls are not customary in the larger buildings, and the cantilever foundation has been devised to meet the need of supporting adjoining walls on their respective curtilages, without the expense of underpinning and guarding against disturbance that arises when spreading foundations which enter upon neighbouring land are used. Cantilever foundations are mostly found in the sky-scrapers of New York.

FIG. 7.—AN EARLY CHICAGO SKY-SCRAPER: BRICK CONSTRUCTION.

Plumbing and drainage in the United States are essentially different from here, as the by-laws do not require all soil pipes &c. to be carried down externally. As a matter of fact this is the exception. Rain-water pipes are occasionally carried down outside. But most of these are taken down inside. The rising mains, soil pipes, &c., are nearly all carried down next to the stanchions, and are so arranged with traps and plugs that they can be readily got at on the different floor levels. Most of the drains, as well as the soil pipes, are of cast iron, water pipes occasionally being of lead, though in most cases they are galvanised iron. The explanation of this sanitary practice is that the

climate does not allow plumbing to be carried down outside on account of frost: even in outside walls it is dangerous in this respect.

I would like to call your particular attention to the large amount of cast-iron work used in the States in the framework of buildings up to twelve stories in height. Cast iron, I believe, could be used to great advantage here for stanchions, as it is a material immediately available, cheap, and always able to be manufactured close to where the work is being done. It is also a material that can be delivered and erected quickly.

FIG. 8.—EXTENSION OF THE BUILDING FIG. 7: STEEL FRAME CONSTRUCTION.

You might like to hear a comparison of cost between buildings in this country and in America. I have made quite a number of comparisons, and can quite safely say that, taking a building as a whole, the cost here would be about the same as in Chicago or any of the Middle or Western cities, which would average about 10 per cent. cheaper than New York City. The explanation is that the difference in the cost of labour is counterbalanced by cheapness of materials.

Now let us consider the so-called "sky-scraper" [fig. 6]. This type of building has more or less revolutionised building practice. It is simply a commercial evolution of a building. Site values had reached such a height that owners began to raise their building heavenward. The heavy rates of all large cities also demanded this. The result was that in a short time property owners were faced with the position that their old buildings, or even new buildings of the old type, would not pay an adequate return on money invested; and, moreover, that the newer buildings with their modern conveniences, such as lifts, telephones, telegraph, heat, electric light, plenty of light and air, &c., and much finer interior fitment, drew away tenants even at increased rentals. The basement and ground floors of this class of building bring in sufficient rental to pay all interest on the freehold or ground lease: the first floor covers all rates and depreciation; the next few stories—their number, of course, depending upon the cost of the building—bring in the interest on money invested to build and all

maintenance expenses; the balance is profit; and all offices being occupied, this generally gives good returns.

In America nearly all property is freehold, except in the central or business districts of the larger cities, where there is a great deal of leasehold property. In connection with this I would point out a principle which I believe, apart from the loss of interest on money invested, has more than anything else caused the American builder to obtain such speed in the erection of this class of structure; that is, that nearly all leases of property (not ground

FIG. 9.—STEEL-FRAME CONSTRUCTION, SHOWING STANCHIONS JOINTED ON EVERY FLOOR.

leases) expire on the first day of May each year, leases running from year to year. The result is that if a building be not ready for tenancy then—it will have to stand practically empty until the following year. This also demands that tenants shall look for new quarters well in advance of 1st May, and the result in many cases is that before a building is a few stories high it is rented for occupancy the following May. Its completion then becomes a necessity, no matter what the cost, otherwise there would be heavy damages for breach of agreement and also loss of rentals.

Property in New York and Chicago in the choicest locations realises as much as £25 to £35 per square foot, and office rentals range from 5*s*. to 17*s*. per square foot, which includes all rates, heating &c. As a rule above the first floor rents increase as one goes up, the top

being the best, as it is quiet and has plenty of light and air. By means of perfect systems of lifts, running express service, no time is wasted in reaching the top floors.

Now and again tales are heard of forty-story buildings. I believe while these could be structurally and safely built, especially if the base were large enough, that the practical commercial building will not be higher than twenty stories, and that will soon be the limit.

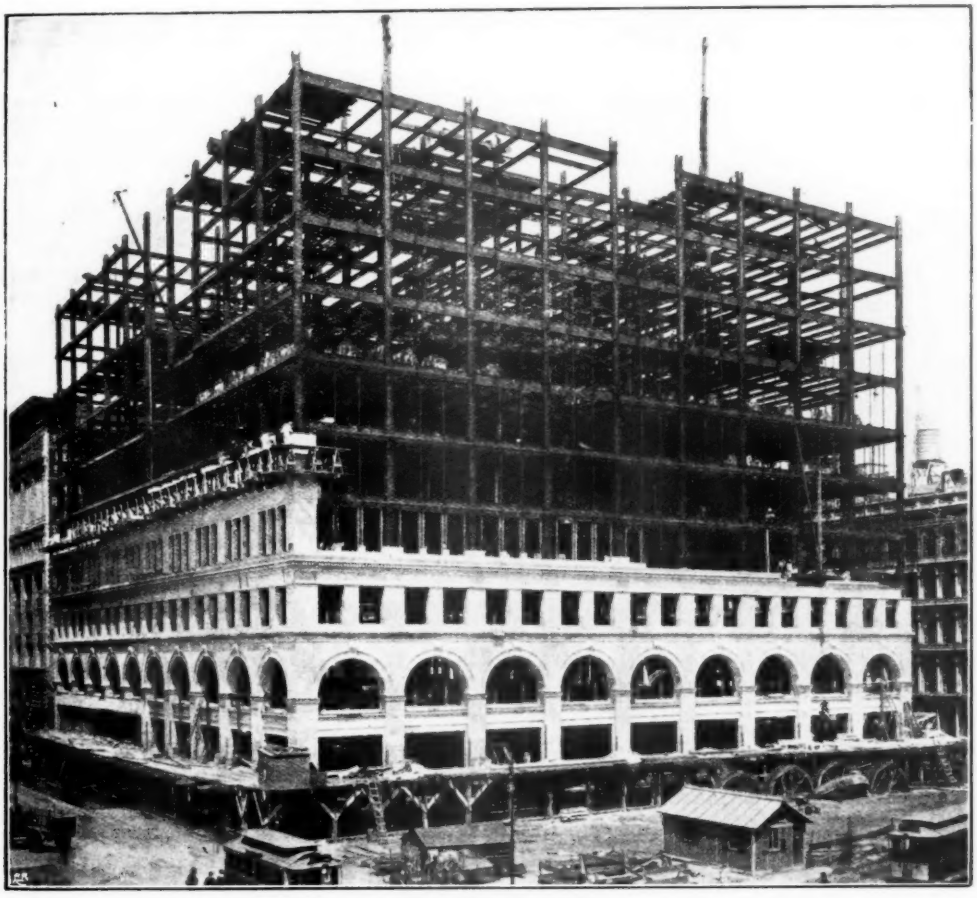

FIG. 10.—STEEL-FRAME BUILDING IN COURSE OF ERECTION.

The cost of maintenance above twenty stories and the great loss of space on the first twenty stories occupied by lifts &c. to reach the upper stories, as well as the increased cost of construction, will not be counterbalanced by the amount of rentable space gained.

I would call your attention to one of the early buildings in Chicago [fig. 7]. This building was erected for some capitalists in Boston (conservative Boston) who, while having faith in the future of Chicago and their capability of letting a sixteen-story building and making it pay a return on the investment, did not deem it wise to build with a steel frame, rather desiring to allow others to experiment first. (What progress would the world make if

this principle were followed by all of us?) This building has all its external walls and piers of brick, no steel being employed, each pier being most carefully calculated for its minimum size, using the very best materials known for bearing great weight. You will see by the photograph that they even went so far as to omit all architectural detail, such as the addition of string-courses &c., which would tend to weaken the piers and make them of greater area. I believe these investors wish to-day they had not been so conservative. While their building has been a success, another photograph [fig. 8] shows how they have extended it one-and-a-half times again in steel-frame construction, thus gaining rentable area lost in their earlier effort.

As regards the life of these steel-frame buildings, when built on proper and now well-known lines their life is as long as that of other buildings. In fact I believe that modern conditions of life are changing faster than buildings depreciate, thus necessitating rebuilding before their life is run. The steel is all buried in concrete, all exterior stanchions being inclosed in brickwork, and the interstices grouted full of cement mortar. The interior stanchions are treated in the same way, bricks or fireclay being used for covering. In addition the stanchions themselves are now being filled internally, while being erected, with concrete, and it is a well-known fact that the inclosing of steel in cement concrete, thus excluding the air, prevents all corrosion.

As to a comparison in cost between buildings supported on steel stanchions and by ordinary brick walls or piers, the cost of carrying a load on a steel stanchion is about one third that of carrying the same load on a brick pier, providing the load is over sixty tons. This can be arrived at by finding the cost of carrying one ton one foot high by the two methods. For the basis of calculation we will assume that the cost of one cubic foot of brickwork is 1*s.*, and that the carrying capacity is six tons per square foot; the cost for carrying one ton one foot high is therefore $\frac{1}{6}^{2}d. = 2d.$ If the cost of a steel stanchion framed complete is £10 per ton, the cost of 1 lb. of metal is $\frac{2}{2}\frac{4}{2}\frac{0}{4}\frac{0}{0}d.$, or about 1*d.* The cost of one cubic inch of metal is therefore about one third of a penny. Assuming that the carrying capacity of an economical section of a steel stanchion is $5\frac{1}{2}$ tons per square inch, the cost of carrying one ton one foot high is about two thirds of a penny. As before stated, the cost of carrying one ton one foot high on brickwork is 2*d.* Therefore by using steel stanchions the cost is reduced to one third of that amount. The above calculations are made without taking into consideration the brickwork wasted in walls which are not loaded to their full capacity, whereas steel can easily be designed to the required section. On the other hand, nothing is allowed for the brick walls which would be necessary according to the building by-laws, the case we have been considering being one where such walls would not be required by the by-laws.

There is also a saving of floor space with steel construction. From the foregoing calculation it becomes apparent that the area of a steel stanchion to carry 60 tons can easily be made 1·46 square foot finished and inclosed, as the sectional area of a brick pier to carry the same load would be 10 square feet. The economised space per foot worked out for all floors at its proper rental value would soon mean a substantial sum which would be well worth considering from the investor's point of view.

Another advantage in favour of the steel frame might be mentioned, namely, its adaptability to the construction of architectural features, as projections outside the main building lines can easily be carried on brackets or cantilevers with little cost and without interfering with the main steel frame. The advantages, too, in the way of planning are great, for walls can be taken out and large areas gained wherever desired.

In regard to the steel frame or the so-called skeleton itself, I will not enter into an exhaustive description. In itself it would make an interesting evening. I wish, however,

to call your attention to a few points. The stanchions of these buildings generally break joint; that is, they are jointed on every other floor, so as to give a stiff frame [fig. 9]. It is also good practice to build the outside girders carrying the walls of plates and angles, making them 2 feet or more in depth, this method generally requiring no greater weight of steel than the usual channels and joists, while certainly adding greatly to the stiffness and rigidity of the frame [fig. 10]. The gusset plates here should also be noted: these are provided with the same object of giving stiffness to the frame against wind strain. In buildings of ten to twenty stories the steel frame is an absolute necessity for stiff and sound construction as well as for the commercial value of the space gained and the rapidity with which this class of structure can be built. One might say it is built in the shop, and that it is only a question of assembling when it reaches the site; dimensions also being necessarily fixed, all interior fitment can be started at once, and when the building is ready can be accurately and quickly put into position. Thus the building's advancement does not entirely depend upon weather or even daylight, as work can be carried forward in the various shops and well in advance. Not only that, but the steel frame can be pushed ahead and the inclosing shell can follow at any floor, working, if necessary, on several stories at the same time, and starting interior work long before the exterior carcass is completed [fig. 11].

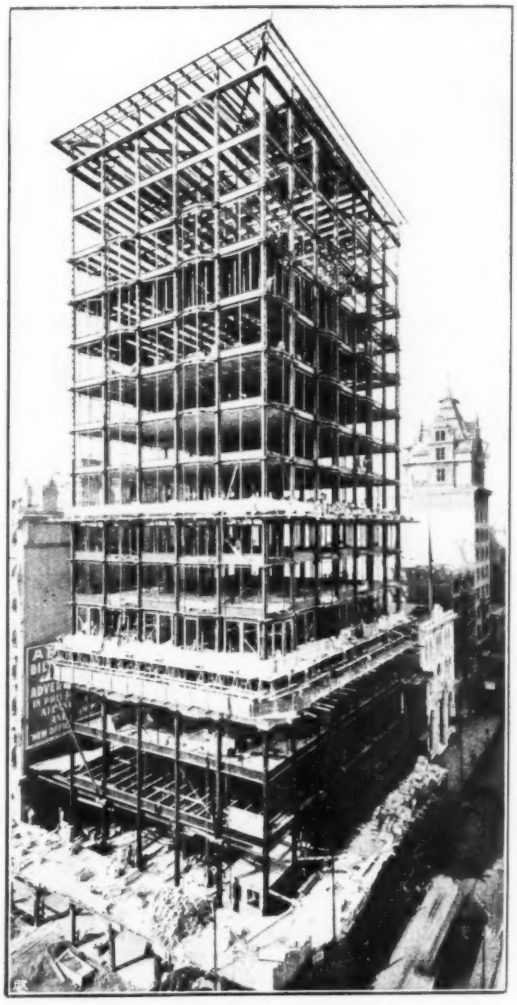

FIG. 11.—STEEL-FRAME CONSTRUCTION: INTERIOR WORK PROCEEDING ON SEVERAL STORIES AT SAME TIME.

You will have noticed the great variety in the design of these buildings,* especially in regard to the expression or otherwise of the skeleton. I would like to draw attention to the use of terra-cotta and the possibilities in this direction when a steel frame is used, as terra-cotta can be attached to this steelwork better than any other material, is more fire-resisting than stone and granite, and allows an ornamental design to be built cheaply. The ornamentation is simply a question of the models which can be used over and over again. Terra-cotta also aids rapidity of construction.

A great many persons feel that rapidity in construction means poor work: this view I strongly oppose. It is possible that such a limit could be reached, and is perhaps

* A large number of lantern slides were shown during the reading of the Paper.

sometimes ; but the general statement that fast work means poor work is untrue. For instance, it could not be called "rushing the work" to have a sufficiency of materials &c. ready to enable a number of men to be engaged all over a large building, doing their work properly, rather than a few men working in one section only and allowing the other sections to stand idle until they were through.

I am aware that there is a good deal of doubt among architects here as to the æsthetic legitimacy of steelwork, as there was in the United States at one time, although the opposition is much weaker now. It seems to me that steelwork is not outside the pale of the art of architecture. I have endeavoured to show that there are logical reasons for the adoption of steel frames in buildings ; and if there is reason, then surely steel cannot be inartistic, any more than timber. There is a question, of course, of the legitimate clothing for the skeleton as to how far this should be expressed ; but there is nothing against the framework itself, no more than the skeleton in our bodies. The analogy might be carried further and the floor construction referred to as the muscles and cartilages, the walls &c. as the flesh, and the hair, colour &c. being the various materials used by the architect to give beauty of detail.

Allow me, gentlemen, in conclusion to say that I think there are a great many things America can learn from England, an older country with much experience. On the other hand, there are things Englishmen can learn from Americans, who have gone ahead with energy, making mistakes, realising them, and beginning afresh again, as all youth does and will when it has the proper grit. The demands of modern life are different, and so are its needs, and we shall not be allowed, even if we should so choose, to stay where our fathers did. Your clients demand, as I have said, rapid and good construction, modern planning, artistic designing, and in fact everything that will render their work successful artistically, commercially, and constructionally, and, what is more, they want it at once.

I would add finally that your best friend is the builder, as you are his. You should work together. He must have plans, details, and instructions complete and definite at the earliest moment in order to accomplish the desired results. Give him full control and make him alone responsible. If you deal with one person for a portion of the work and with another for something else, you not only relieve the builder of a portion of that responsibility, but you actually hamper his progress, for then the other person looks to you and not to him.

## DISCUSSION OF THE FOREGOING PAPER.

The President, Mr. John Belcher, A.R.A., in the Chair.

Mr. BENJAMIN GREENWOOD, President of the Institute of Builders, who rose at the invitation of the President, said it was his privilege to move a vote of thanks to Mr. Denell for his most interesting Paper. They were, he thought, filled with admiration for American methods, but they were not perhaps filled with envy. They admired what ingenuity could do, without being particularly anxious to do the same thing themselves. He was sure the circumstances which obtained in America would not fill the architectural profession with envy, as Mr. Denell stated that the remuneration of architects was the same as in England, but that there was very much more work required ; and the enormous staff which it appeared necessary for an American architect to retain was somewhat appalling. As to the surveyor, he was extinct in the United States; so quantity surveyors were not likely to be enamoured of the American system. He was sure the builders were not:—1*s.* 10½*d.* to 2*s.* 11*d.* for a mechanic per hour! And take out all your quantities yourself! He could assure them there was no envy on the part of the builders. They would not be desirous to emigrate just yet, for they thought that more favourable circumstances prevailed in the old country. He was surprised to hear of the custom in America of separate contractors being employed upon the same building for the different trades. In the old ages, and sometimes in the northern counties and Scotland, that

custom still prevails; but he should have thought that, with the rapidity of construction which obtained in America, the whole contract would be put into the hands of one contractor. Under the circumstances described in the Paper, if the different trades were put into the hands of different contractors, it became all the more phenomenal that such buildings could be erected in the space of time mentioned. He did not think the lofty buildings would ever be adopted in this country. It was like living in a pit to walk through the streets with such buildings on either side. Perhaps, after all, it was a fortunate thing that the first experiment made in London in the way of high buildings was such a monstrosity. He referred to the building near St. James's Park. He always thought that this was a thing to be regretted, but perhaps, after all, it was a blessing in disguise! It had given them such a horror of that kind of thing that it might at all events stave it off perhaps for many generations to come. With reference to the British bricklayer, who had been vilified in the Press, he might say that the gentlemen who wrote those letters were comparing what the bricklayer did then, with what he had done in bygone years. He believed that the correspondence was justified at the time it was written, because a few years back there was no doubt that the output of work from the average English bricklayer was very much less than it had been a few years before. But those things altered when trade became slack, and the bricklayer knew that there were three or four men waiting outside to do his work; he would then do a more satisfactory day's work to keep himself in employment. It was delightful to hear the way they allocated the duties of the different floors in these high buildings: the ground floor to pay the ground rent &c., the next floor to pay the rates, the next floor the expense of erection and so on, and all the rest was profit—it was delightful in theory, and it would be more delightful in practice. Another extraordinary thing they had learnt was that the top floor was the highest in rental value, as it is quiet and has plenty of light and air. If they could only persuade Englishmen to believe that, they would accomplish a most desirable thing—not perhaps from the builder's point of view, but certainly from the property owner's. In conclusion the speaker moved a most hearty vote of thanks to Mr. Denell for the large amount of interesting information he had conveyed to them in so short a space of time.

Mr. JOHN SLATER [*F.*], in seconding the vote of thanks, said that Mr. Denell had shown them a large number of buildings which, whatever might be thought of them architecturally or æsthetically, were undoubtedly interesting. The recent work of the American companies in London had been of much interest to architects and builders, because of the great rapidity with which the buildings were run up. He was not sure, however, that this rapidity of construction was altogether a good thing. He presumed that nearly every architect who had had designing of buildings to do must have felt, as his work went on, that he wished to make certain little alterations here and there to improve his building; and, so far as he knew, the system of construction the American syndicates adopt practically precluded any variation when once the building was started. He was not sure that that was for the best for the finished building. With regard to what had been said about the English bricklayer, some few years ago he happened to have an experience of some Continental bricklayers. He had to look after the building of a lager-beer factory in this country, and the whole of the work was done by a German contractor, who imported German bricklayers here; and he was bound to say that it was an absolute revelation to him to see the way these bricklayers worked. They did in one day what the ordinary English bricklayer would have taken three days to do. He was not concerned to support or oppose the various trade unions; but they were told that the trade unions forbade bricklayers to lay more than a certain number of bricks per day. If that were the case the workmen themselves gave up all their individuality; there was no preference to be given to a good workman over a bad workman, because they were all brought down to the same hard-and-fast line. That was not the best system for getting the best work out of the individual man. Mr. Denell had said something about each city in America having its own building department, and that the larger cities had a competent staff to deal with building works and to calculate the strength of the various parts from the drawings. He maintained that that was no business of the municipality at all. The London County Council were doing the same thing now, and he maintained that they were taking upon themselves a responsibility which was not theirs at all. They were using up the time of their staff in a way they ought not to do, because if an architect or an engineer designed a building, the responsibility as to its safety and methods of construction was his. It was not wise of municipalities or county councils, or any body of that kind, to take upon themselves to go over the work of an architect who sent in drawings to ascertain whether his scantlings were sufficient, or that sort of thing. If the municipal bodies did this work, they relieved the architect of responsibility altogether, and although probably no architect would wish to be relieved of that responsibility, it was well known that a large number of buildings were put up in London and elsewhere without an architect at all; and if the municipal body took upon themselves the responsibility of saying whether those buildings were safe or not, the builder would care nothing at all about it, and there was a risk with the

municipal body of its subordinates being wrong, just as much as there was with the ordinary designer. He ventured to hope that they would not see in London any constructions like some of those shown them on the screen. There was one in particular, a building some 17 or 18 stories high that seemed little more than 12 feet wide. He personally could never inhabit any room of such a building without the feeling that it might be blown down. Apart, however, from criticisms of that kind they were very much indebted to Mr. Denell for giving them these particulars of American construction. Whatever they might think of them, it was evident that the methods would be employed here, and the more they knew about them, the better they would be able to decide whether it would be worth their while to employ such systems as these, or to depend upon the old, more conservative, and perhaps more reliable methods of the ordinary English contractor.

MR. HOWARD COLLS, asked by the President to speak, referred especially to the fear that such tall buildings as those shown them should be erected in London. One of the most charming—at least what they in America called most charming—buildings in New York was the "Flat-Iron" Building. But the draught there was so strong that no lady could walk by the side of that building—she would be frightened to do so: her clothes would become disorganised and be blown to pieces. Some of the buildings he had seen in New York were very high, two of them at the entrance of Fifth Avenue struck him as imposing-looking, because they formed a sort of noble entrance to that thoroughfare. But they were isolated and opposite each other. If buildings like these had been erected all along the street, and the general buildings of New York were of that height, there would never be any sun in the streets at all; and he doubted if anybody would be able to walk about there. It would be obvious to everybody that if they put up buildings in streets which prevented the streets being used, the result could not be considered satisfactory. There seemed to be an idea that a quickly erected building must necessarily be an advantage. Speed of course was very desirable, but the American system was not so much a system of speed as of intense hurry. They never seemed to do anything quietly or thoughtfully—they did it in the quickest possible time that it could be done in. If one goes to America one can have one's boots cleaned, one's hair cut, and one's hands manicured at the same time! Everything seemed to be done there with that idea; and what he feared was that this system of hurry could not be conducive to good work. They talked about the splendid work of old days: when a man built a mansion, he would put up the brickwork one year and leave it, put the plaster on the next year and leave it, and do the joiner's work the following year; and the result was magnificent. That system, of course, could not obtain now. But the mere love of hurry, for hurry's sake, was a grave disadvantage in modern buildings. No building that was constructed beyond a certain speed could possibly be as good as one which was more leisurely, but still speedily and properly done.

MR. WM. WOODWARD [*F.*] said that if there was a man in that room from whom he should not care to differ it was his friend Mr. Howard Colls; but he thought Mr. Howard Colls and both the previous speakers had rather misapprehended the purpose of the Paper. He had not detected in the Paper any desire whatever on the part of Mr. Denell, even to suggest that they should adopt in London the buildings which prevailed in America. His object rather was to tell them exactly what took place in America, so that they might perhaps even in London, gather some lessons which would be useful to them, bearing in mind the fact that they must not rest quietly with the old methods of construction, but must go with the times, and conform to those requirements which were certainly as much needed in London as they were in America. He thoroughly agreed with what Mr. Slater had said with regard to some of their municipal authorities taking upon themselves responsibilities outside their province. Not only that, but in taking those responsibilities upon themselves they considerably hampered the architect in his dealing with the building. Architects in London were quite as capable of designing buildings with perfect construction as any employé of our borough councils or the London County Council; and he thought those bodies went out of their way to hamper the architect in the execution of his work; to entail, as they often did, considerable unnecessary expense; and to retard the building to the detriment of the client in every particular. Mr. Denell had spoken of the bricklayer, and said that our tirade should not be confined to him. He quite agreed. They only selected the bricklayer because one could count the number of bricks a man could lay in a day, but it was not so easy to count the yards superficial of the plasterer's work. But if there was one individual in the building trade who should bring himself under the castigation of everyone who desired honest labour and manliness in the building trade, it was the plasterer. The plasterer was quite as bad as the bricklayer—some thought he was a great deal worse. But it was not the fault of the bricklayer. Mr. Denell had said that the English bricklayer was capable of doing as excellent work as any foreign or American bricklayer. Although Mr. Slater had trodden upon the question very gently, he (the speaker) did not hesitate to say that the present state of idleness was due to one thing, and one thing only, and that was trade unionism.

It was just as well that they should have it out and say at once, that was the sole reason. Mr. Denell had said that the wages in America ranged from 1*s.* 10½*d.* to 2*s.* 11*d.* per hour for an eight hours' day, and for labourers from 1*s.* to 1*s.* 6*d.* He took that to mean that in America the trade union principle of levelling everyone down, as Mr. Slater had said, did not prevail; otherwise those wages would not range from 1*s.* 10½*d.* to the higher amount per hour. Therefore he hoped that in that respect the British workman might learn a lesson and find that the idea that an honest, healthy, and upright man should be confined to the same wage as the idle and drunken was ridiculous and absolutely wrong. There was one important matter which prevailed in America, and sometimes prevailed in London, and ought to prevail a great deal more, and that was looking ahead. Very often the whole secret of delay on a building was because the builder or builder's foreman had not sufficiently looked ahead; and he differed from Mr. Howard Colls in that respect. He did not see why a building should not be quite as good if it were rapidly erected as one that was slowly erected, provided there was space for the various operatives to do their work. There was no reason whatever to his mind why these large buildings should not be done as easily and well in six months as in twelve, given certain conditions. With regard to sub-contractors, he thought that the fewer sub-contractors there were on a building the better. It was the idea of sub-contractors on buildings which led to so much delay and created so much friction between the sub-contractor and the general contractor. With the few exceptions of expert matters, there was no reason whatever why the general contractor should not carry on his building and embrace within his charge the whole work of the sub-contractors who were now employed. With regard to the absence of a quantity surveyor, that might or might not be conducive to rapidity. If the quantities were properly taken, he could not see why one man or two men should not take out the quantities as well as twenty different contractors. But perhaps in America they had some more rapid system of arriving at estimates than we have in this country. Whether the builders suffered or whether the clients suffered he did not know. There was another very important matter which concerned architects now. In very large buildings (he was not speaking of ordinary buildings) demanding steel construction, the architect of to-day—at least he would speak for himself—was not capable of doing the whole of the important constructive steel engineering work. There were, as they knew, certain architectural engineers who designed this construction, and in America they had engineers for this work. But a question that would arise for the architectural profession soon was, Whether the designing of this important engineering work was part and parcel of the architect's duty for which he should be paid, or whether it was part and parcel of the engineer's duty, which the client should pay for apart from the charges of the architect? In every large building that important question must arise; and a hint as to how it could be met could be got from the system adopted in America, where Mr. Denell told them that although the engineering design was made in the architect's office, the contractor was entirely responsible for the details of the engineering work carried out. There was one other important matter where they could wish that the American system prevailed in London. Each city had its own building department, which was the only authority to be consulted. Would that that system prevailed in London, and that having taken our drawings to one department we could come away from that department with the buildings approved or disapproved, without having to go to half a dozen authorities, each with its own fad, before the work could be proceeded with. With reference to terra-cotta, there was another thing from which they might take a lesson from America. If they could not afford fire-resisting construction, they might at least adopt terra-cotta covering. There were inventions, too, for treating timber which would make it practically as fire-resisting as steel and concrete. Steel framework was now coming largely into use in London, and he believed the whole Meeting would be with him in thanking Mr. Denell most heartily for having concentrated in a short Paper such valuable information, giving exactly what took place in America—something which they might remember and perhaps adopt in London.

Mr. ANDREW T. TAYLOR [*F.*], late of Montreal, Canada, said he was very glad of the opportunity of saying a word or two upon the subject, as it was one he had been intimately acquainted with for some time. He should like to congratulate the lecturer upon the simple, straightforward practical Paper he had given them. As they said in the States, he had put no frills on, but had given them a very delightful practical Paper. He had not expressed any opinions of his own, but simply put before them facts; and he thought that was what they wanted. He would also congratulate him upon having disclaimed all responsibility for the title of his Paper. He (the speaker) took exception to the title "American methods of erecting buildings." Speaking for Canada—the larger part of the North American continent—he thought it should have been "United States Methods." It was sometimes forgotten that we have a magnificent possession on the other side, which was as fine, and would in time be finer than the United States. The United States recognised that themselves, because their people were coming over to Canada at the rate of 50,000 a year, foreseeing that the future was going to be in the North

of America and not in the South. He endorsed almost everything that the lecturer had said. After all, the great difference of procedure between here and the United States lay in the evolution of the sky-scrapers. But before touching on these might he be permitted to say that he thought the gentleman who proposed the vote of thanks had misunderstood the lecturer on one point? The lecturer did not say—at least, so far as he gathered—that the contracts were divided amongst the several trades. They were generally taken by one contractor; but if the work was large he sub-let it himself to other contractors; the architect only, however, dealt with the one contractor. It was manifestly impossible that with a building costing, say, from five to ten million dollars, one man could do the whole work himself, and that was where the quickness and rapidity of operation came in. The moment the contractor had signed the contract, the architect had all the details ready, and that meant a good deal of work. It was not the custom here, and in some other places, to do that; but everything must be detailed, and every part of the design completely elaborated by the time the contractor signed the contract. What was the result? Every department of operations could start at once with its work. While the steel frame was going up the stone work was being cut, and before the steel frame was finished probably the stone work was ready to go up; and so, too, with the work inside: the joinery work, the plastering and other work. The moment the building was ready for it, the various finishing works were ready to be put in. In that way, by mapping out everything carefully in the beginning, one can get speed. In regard to what Mr. Slater had said, from his (the speaker's) own experience on the other side of the Atlantic, it was very essential that the municipal authorities should have some right of veto upon the plans put before them. It must be remembered that many architects on the other side were not duly qualified; some were only just builders who had blossomed into architects; so that many plans were sent in for signature with a good many things far from being right, and it was absolutely necessary that there should be some authority in municipal matters who would be competent to deal with them. They had seen several cases in which buildings erected in New York had fallen down before they were finished; that was simply because the municipal authorities were remiss as well as the original designers of the structures. He had occasion himself to take part in the drawing up of by-laws for a city, and in view of that he had to examine the by-laws of the principal cities in the United States; so that he was not speaking merely from hearsay. He was quite sure that the drawings of the members of the Institute would not require any such supervision, but they were not all members of the Institute on the other side. With regard to sky-scrapers, of course the question of design did not come before them that evening—it was only their construction. But the two were so joined together that it was very difficult to discuss the one without trenching upon the other. He would only say in a word that of all the hideosities the sky-scrapers were the worst, and he trusted they would not be allowed to come and blossom and grow up on this side of the Atlantic. They had ruined some of the finest streets in New York, and if they went on they would have canyons and caves instead of streets. Streets at least 300 feet wide were required to admit of sky-scrapers; that meant laying out the cities *de novo*. In some of the streets running from Broadway the blasts and gales which sometimes drove down them were most alarming. With regard to the "Flat-Iron" Building, it was the fact that people had been blown off their feet, and it was not an uncommon occurrence for the plate-glass windows of the buildings opposite to be broken. He was not so sanguine as the lecturer of the durability and life of those high buildings. That side of the problem had to be faced. The lecturer seemed to think that casing the steel construction in cement was all right. Whatever was the custom to-day—and they were very much more careful than they were some years ago—he knew this, that when they began those buildings, and for many years after, so great care was not taken; that the painting was very faulty, and rust commenced on the steel uprights. Then they were inclosed in wet brickwork and covered up and no more seen. He very much feared that rust and deterioration were going on inside those brick piers, and some day there might be a catastrophe. It was awful to think what would be the result. Their duration of existence had been too short yet to admit of a satisfactory test, but in fifty or sixty years he very much feared that something of that sort would happen. He cordially supported the vote of thanks.

MR. E. W. HUDSON [*A.*] said he understood that an existence of 25 years was reckoned to be a remunerative return for the capital expended, and that after that these high buildings might be made scrap-heaps. When the lecturer spoke of their lasting as long as other buildings, they might perhaps have some standard as to the age of those other buildings.

THE PRESIDENT said that in putting the vote he should like to add his thanks for the Paper, which had raised so many interesting points of discussion. There was no doubt that we could learn, and had learned, a great deal from the American; but we allowed him first of all to make the trial and experiment, and then if it succeeded, we followed; and if the world progressed he had no doubt it was owing very much to American energy and "go." We in this country and the countries of Europe generally moved much more slowly; we

looked upon everything that was novel with some suspicion. Indeed, if we architects suggest to a client that some new method should be adopted, he immediately turns upon us and requires to know where this had been done before and where he could see it, or whether it was so done in the days of Queen Anne! In America it was different. There everything that was novel was approved of, and youthful daring of any kind was extolled and accepted. If a man made an experiment in America and succeeded he was soon raised to a position of distinction and honour, and made his pile. If it failed, the country was so large that he could move a thousand miles off and start again! Mr. Denell had told them many things of value and interest, and he had certainly in two or three instances made them gape with astonishment; for instance, with regard to an architect's establishment costing £50,000 a year, and that his remuneration was the same as ours. Whether the architect was expected to get out the quantities and keep a tame engineer on the premises and other luxuries he did not know. There must be some means of obtaining a *quid pro quo*. No doubt the extra cost of a building made a commission of five per cent. considerably beyond what it was here. They had learned also that builders sometimes passed through an architect's office, and that the builder took out his own quantities (they seemed remarkably trusting in America); that they make out plans and specifications, he presumed, for the sanitary and mechanical and frame-building construction; and that was all to save the architect trouble and to relieve him of unnecessary worries. That was exceedingly satisfactory and nice, but of course it must be paid for; and he had no doubt the extraordinary cost of the buildings would somewhat recoup them. What was the gain therefore? They got increased speed in execution, but, as the scientific men told them, they could not have something for nothing; so that if they wanted increased speed, they must pay the corresponding additional cost of the "power." He thought they had learned two lessons from the Paper: one, that they must not lag behind; and the other, that they must take every advantage of all the improved methods that they could consistently with the production of good work. In the steel-frame work they had a very serious problem, and he could not help feeling that if anything of that sort were developed to any great extent, they should all have to become engineers instead of architects. Architects seemed to him in such cases to take a very secondary place, and it was necessary for them to look the thing in the face and ascertain whether they were in a position to become engineers as well as architects.

MR. DENELL, in reply, said he had been asked to read a Paper on "American Methods of Erecting Buildings." That meant a great deal. It was not the why, the pros and cons of what should be done in England, but "American methods of erecting buildings." That was what he had tried to explain. He knew perfectly well that the laws here were different, and that the conditions were different; and so he thought the quickest way round was straight there first, leaving it to architects to apply and do as they wished in regard to it. With regard to the labour wage, he might explain that it depended upon the trade. The bricklayer or a steel erector, where it was dangerous work, received perhaps the highest; the wage of carpenters and others depended upon their work; and it was all fixed by the unions. As regards the unions, he hoped they in England would never have the experience that they had in America. With regard to work being done by sub-contractors, what he meant to convey was that the builder was the general contractor, but he sub-let work again—that was done in the shop; the other work he did himself. The architect only dealt with the builder. The custom there was not for the builders to have their shops as was the case here. With regard to the life of the buildings and the corrosion of steel and concrete, he saw a gentleman among them that evening – M. Mouchel—who might say a few words on the subject.*

THE PRESIDENT, in bringing the proceedings to a close, directed the attention of the Meeting to a number of drawings on the walls kindly lent by Mr. Denell in further illustration of his subject.

* See M. Mouchel's Paper on "Hennibique Ferro-concrete" [JOURNAL for 26 Nov. 1904.]

# THE PRUSSIAN GOVERNMENT REGULATIONS FOR THE USE OF REINFORCED CONCRETE IN BUILDINGS.

THE following translation of these rules, for which the Institute is indebted to Mr. Wm. Dunn [*F.*], may be of interest to architects and engineers engaged on works of reinforced concrete:—

## I. General Regulations.

### A. *Examination.*

§ 1.

1. A special examination by the buildings authority must precede the erection of any building or portion of a building in reinforced concrete. For this purpose, any application for permission to erect a building to be constructed in whole or in part in reinforced concrete must be accompanied by drawings, statical calculations, and descriptions, from which the general arrangement and all important details may be seen.

Should the building owner or contractor only decide during the progress of the erection on the form of construction to be adopted, the building authority must demand the production of the above data.

2. The origin and nature of the materials to be employed in the preparation of the concrete, and the proportions in which they are to be mixed, must be stated in the description.

3. The application must be signed by the building owner and by the contractor charged with the erection.

§ 2.

1. The quality of the materials to be employed in the preparation of the concrete must be attested by certificates from an official testing station. Such certificates shall in general be not more than one year old.

2. Only Portland cement fulfilling the Prussian specifications may be employed. The certificates as to quality must contain statements as to the constancy of volume, time of setting, and fineness of grinding, and also as to the tensile and compressive strength.

3. Only sharp sand, gravel, or other recognised material of suitable coarseness may be employed in the preparation of the concrete.

4. The compressive strength attained by the concrete to be employed, when mixed in the prescribed proportions, after 28 days, must be stated in the description (§ 1, par. 1)

§ 3.

1. The method of statical calculation employed must ensure at least the same degree of safety as that calculated by the rules contained in Section II. of these Regulations.

2. In methods of building yet untried, the building authorities can make their approval dependent on the results of previous experimental structures and test-loads.

### B. *Erection.*

§ 4.

1. The building authority may cause the quality of the materials in course of employment, and also the strength of the finished concrete, to be examined at an official testing station, or in such other manner as may appear desirable. The strength tests may also be carried out on the works by means of a concrete press, the accuracy of which has been certified by an official testing station.

2. The concrete blocks intended for testing must be of cubical form, 20 or 30 cm. edge * according to the coarseness of the aggregate. The blocks must be marked with the date of preparation and stamped for identification, and preserved according to the instructions of the building authority until hardened.

3. The cement is to be delivered in the original packages.

§ 5.

1. The concrete is, as a rule, to be mixed by weight.

2 The measuring out may, however, be performed by means of gauging-boxes, a separate gauging-box being used for each material. Each such gauging-box shall contain, when filled and struck off level, the quantity corresponding with the prescribed mixing proportions, as determined by a trustworthy weighing machine.

§ 6.

The concrete is only to be prepared in such quantities as are required for immediate use. It must be put in place immediately after mixing and uniformly rammed. If in a plastic state, the ramming must be continued at least until water appears on the surface. In ramming, properly shaped stamps of appropriate weight must be used.

§ 7.

1. Especial care must be taken that the ironwork for reinforcement is correctly placed and thoroughly coated with cement mortar.

2. The concrete is to be filled in in separate layers not exceeding 15 cm. in thickness, each layer being thoroughly rammed.

3. Main walls must be commenced and raised simultaneously throughout their whole length. Care must be taken to make good connection with adjoining cross-walls. Layers which complete a story must be finished off level.

4. The planking must possess sufficient resistance to bending and to shaking during ramming, and must be so arranged as to be removable without danger to the necessary supports remaining in place.

* 8 inches to 12 inches.

5. All shaking must be avoided in removing the planking and supports.

§ 8.

1. When a fresh layer of concrete is to be laid on the surface of a recently laid layer, it is sufficient to wet the surface thoroughly.

2. When work is recommenced on a layer of hardened concrete, the old surface must be scraped, swept clean, and wetted.

§ 9.

In the construction of walls and columns in buildings of more than one story, the erection of those parts in an upper story is not to be commenced until the story below has been approved.

§ 10.

1. Work is not to be carried on during frost, except in cases in which the possibility of damage by frost is excluded.

2. On the beginning of milder weather after long-continued frost, work is only to be recommenced after the permission of the building authority has been obtained.

§ 11.

1. Until sufficiently hardened, the concrete must be protected from the action of frost or from premature drying, and also from shaking or overloading.

2. The vertical centering of concrete columns and the flat centering of floors of 1·50 metre span or under may be removed not less than three days, all other centering and struts not less than 14 days, after the completion of the ramming.

3. Should the ramming be completed shortly before the commencement of frost, especial care is to be taken in removing the centering and struts.

4. Should frost commence during the period of hardening, the periods prescribed in § 2 are to be increased by the duration of the frost.

§ 12.

A time-book of the work is to be kept, and must be at all times open to inspection on the works. Days of frost must be entered, with a record of the temperature and of the time of day at which it was measured.

C. *Approval.*

§ 13.

1. When inspected for approval, portions of the building must be exposed, in positions determined by the building authority, so that the mode of construction may be seen. The right to make special tests to determine the quality of the material, the hardness attained, and the strength is reserved.

2. Test-pieces for the determination of the hardness according to § 4, par. 2, may be taken from portions of the finished building.

3. Should loading tests be considered necessary, they are to be carried out according to the instructions of the representative of the building authority. Due notice is to be given to the building owner and the contractor, and their attendance invited.

4. When a strip cut from the floor decking is subjected to a loading test, the load is to be uniformly distributed over the whole strip, and is not to exceed the weight of the floor and twice the working load. Should such a strip be tested without removal from the floor, this load is to be increased by one-half. Consequently if $g$ = the dead load and $p$ = the live load, the test load in the former case is $g + 2p$, and in the latter $1{\cdot}5g + 3p$.

II. Rules for Statical Calculation.

A. *Dead Load.*

1. The weight of concrete, inclusive of the metal for reinforcement, is to be taken as 2400 kg. per cubic metre,* unless a different weight is definitely determined.

2. In the case of floors, in addition to the weight of the structural portions, the weight of the flooring material is also to be ascertained from accepted data.

B. *Determination of External Forces.*

1. In members subjected to bending, the moments and reactions are to be calculated by the formulæ for freely supported or continuous beams, according to the mode of support and distribution of load.

2. For freely supported decking the free opening plus the depth, for continuous decking the distance between centres of supports, is to be taken as the span.

3. For decking, which is continuous over several spans, the bending moment in the middle of a panel is to be taken as four-fifths of that which would exist in a freely supported panel,† unless the true moments and reactions can be ascertained by calculation or experiment.

4. The same rule holds good for beams, T-beams, and detached girders, with the exception, however, that no end-moment is to be taken into account unless special structural arrangements for fixing the ends securely have been made. The span is to be taken as the free opening plus the width of one support.

5. For T-beams the flange is not to be taken into account for a width of more than one-third of the length of the beam.

6. For columns the possibility of eccentric loading is to be taken into account.

C. *Determination of Internal Forces.*

1. The modulus of elasticity of steel is to be taken as fifteen times that of concrete unless a different ratio is ascertained.

2. The stresses in the cross-section of members subjected to bending are to be calculated on the assumption that the extension is proportioned to the distance from the neutral axis, and that the reinforcing metal takes the whole of the tensile stresses.

3. Shearing stresses are to be ascertained, unless the form and construction of the members are such that they are at once seen to be insignificant. When no means of taking them up are provided in the arrangement of the members, they must be taken up by suitably shaped steel reinforcement.

* 150 lb. per cubic foot.

† Bending moment = $\frac{Wl}{10}$ for uniformly distributed loads.

4. So far as possible, the steel for reinforcement is to be of such form that displacement relatively to the concrete is prevented by its form. Where this is not the case, the adhesive stresses must be calculated.

5. Calculations of the flexure of columns are to be made whenever the height exceeds eighteen times the least diameter. Transverse connections, so arranged as to maintain the steel rods in their relative positions, are to be fixed at a distance from each other not exceeding thirty times the diameter of the rods.

6. Euler's formula is to be used in calculating the flexure of columns.

### D. *Permissible Stresses.*

1. In members subjected to bending, the compressive stress in the concrete shall not exceed one-fifth of its ultimate compressive strength; the tensile and compressive stresses in the steel shall not exceed 1200 kg. per sq. cm.*

The following values of the loads are to be assumed:

(*a*) For parts of structures subjected to moderate shaking, as floors of dwelling-houses, offices, and shops: the actual live and dead loads.

(*b*) For parts of structures subjected to considerable shaking or to greatly varying loads, as floors of public halls, dancing-rooms, factories, or warehouses: the actual dead load and 50 per cent. over the live load.

(*c*) For parts subjected to heavy shocks, as roofs of vaults underneath passage-ways and courtyards: the actual dead load plus twice the live load.

2. In columns the concrete is not to be stressed beyond one-tenth of its ultimate compressive strength. In calculating the steel reinforcement for flexure a factor of safety of 5 is to be allowed.

3. The shearing stress in the concrete is not to exceed 4·5 kg. per sq. cm.† When a greater resistance to shearing is shown, the working stress is not to exceed one-fifth of the ultimate strength.

4. The adhesive stress is not to exceed the permissible shearing stress.

## III. Methods of Calculation with Examples.

### A. *Simple Bending.*

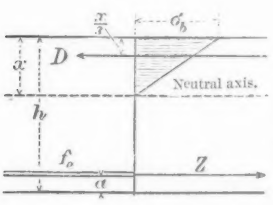


FIG. 1.

With simple reinforcing rods of area $f_e$ for a width of beam or decking $b$, $n$ being the ratio of the coefficient of elasticity of the steel to that of the concrete, the distance of the neutral axis from the upper edge follows from the equation of the statical moments of elements of area:

$$(1) \qquad \frac{bx^2}{2} = nf_e\,(h - a - x) \text{ and}$$

$$(2) \qquad x = \frac{nf_e}{b}\left[\sqrt{1 + \frac{2b\,(h-a)}{nf_e}} - 1\right]$$

Equating the moments of the external and internal forces:

$$(3) \quad M = \sigma_b \cdot \frac{x}{2} \cdot b\left(h - a - \frac{x}{3}\right) = \sigma_e f_e \left(h - a - \frac{x}{3}\right)$$

where $\sigma_b$ is the greatest compressive stress in the concrete, and $\sigma_e$ the mean tensile stress in the steel. Hence

$$(4) \qquad \sigma_b = \frac{2M}{bx\left(h - a - \frac{x}{3}\right)}$$

$$(5) \qquad \sigma_e = \frac{M}{f_e\left(h - a - \frac{x}{3}\right)}$$

The calculation remains the same for T-beams if the neutral axis lies in the flange itself or at the lower angle between flange and web. If the neutral axis lies in the web, the small compressive stresses in the web may be neglected.

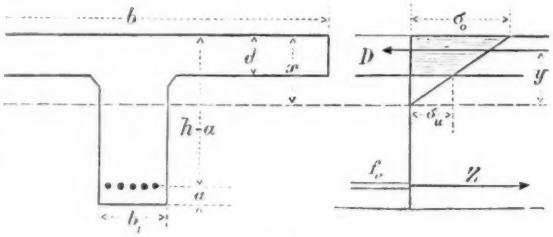


FIG. 2.

Then (fig. 2)

$$\sigma_u = \sigma_o \cdot \frac{x - d}{x}$$

$$\sigma_e = n\sigma_o \frac{h - a - x}{x}$$

$$\frac{\sigma_o + \sigma_u}{2} \cdot bd = \sigma_e f_e$$

or, inserting the given values of $\sigma_o$, $\sigma_u$, and $\sigma_e$,

$$(6) \qquad x = \frac{(h-a)\,nf_e + \frac{bd^2}{2}}{bd + nf_e}$$

Since the distance of the centre of gravity of the polygon of pressures from the upper edge is

$$x - y = \frac{d}{3} \cdot \frac{\sigma_o + 2\sigma_u}{\sigma_o + \sigma_u};$$

then, inserting the above value of $\sigma_u$

$$(7) \qquad y = x - \frac{d}{2} + \frac{d^2}{6\,(2x - d)}$$

$$(8) \qquad \sigma_e = \frac{M}{f_e\,(h - a - x + y)}$$

* 17,000 lb. per sq. inch. † 64 lb. per sq. inch.

$$\sigma_o = \sigma_e \cdot \frac{x}{n\,(h - a - x)} \tag{9}$$

B. *Centric Pressure.*

If $F$ is the area of the concrete surface under pressure, and $f_e$ that of the total reinforcing metal, the working load is

$$P = \sigma_b\,(F + nf_e) \tag{10}$$

so that

$$\sigma_b = \frac{P}{F + nf_e} \tag{11}$$

$$\sigma_e = n\sigma_b = \frac{n \cdot P}{F + nf_e} \tag{12}$$

C. *Eccentric Pressure.*

The calculation is made as in the case of homogeneous materials, except that in the expressions for cross-sectional area and moment of inertia $n$ times the cross-section of the reinforcing metal is added to the section of the concrete. Any tensile stresses produced must be taken up by the reinforcing steel.

D. *Examples.*

**1.** To determine the maximum stresses occurring in the concrete and the steel of a dwelling-house floor, 2 metres wide and 10 cm. thick, with reinforcing steel of 5 sq. cm.

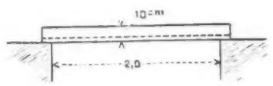


FIG. 3.

section for each 1 metre width of floor, the steel being 1·5 cm. from the lower surface.

The dead load of the floor per sq. metre is

| | |
|---|---|
| 0·1 × 2400 = . . . . . | 240 kg. |
| Covering with rolled slag 10 cm. thick . | 60 ,, |
| Wood floor 3·3 cm. thick with . . | 20 ,, |
| Plaster 1·2 cm. thick . . . . | 20 ,, |
| Live load . . . . | 250 ,, |
| Total . . . | 590 kg. |

Then:

$$M = \frac{590 \times 2{\cdot}1^2 \times 100}{8} = 32500$$

$$x = \frac{15 \times 5}{100}\left[\sqrt{1 + \frac{2 \times 100 \times 8{\cdot}5}{15 \times 5}} - 1\right] = 2{\cdot}9 \text{ cm.}$$

$$\sigma_b = \frac{2 \times 32500}{100 \times 2{\cdot}9 \times (8{\cdot}5 - 0{\cdot}97)} = 30 \text{ kg. per sq. cm.}$$

$$\sigma_e = \frac{32500}{5 \times 7{\cdot}53} = 865 \text{ kg. per sq. cm.}$$

The compressive stress allowable in the concrete is 30 kg. per sq. cm. if the concrete employed has an ultimate compressive strength of 5 × 30 = 150 kg. per sq. cm.

**2.** Given a freely supported flat flooring slab with simple reinforcement and of 2 metres span. The live load is 1000 kg. per sq. m. for a factory. To determine the requisite thickness of the concrete and the steel, assuming the concrete employed to have an ultimate compressive strength of 200 kg. per sq. cm.

For calculating the dead load, the thickness of the slab may be taken provisionally as 15 cm., so that the span to be used in calculation is 2·15 metres.

The dead load for a slab per sq. metre is

| | |
|---|---|
| 0·15 × 2400 = . . . . . | 360 kg. |
| Covering with rolled slag, 20 cm. deep . | 120 ,, |
| 2 cm. layer of cement . . . . | 40 ,, |
| Total | 520 kg. |

Then

$$M = \frac{520 + 1{\cdot}5 \times 1000}{8} \times 2{\cdot}15^2 \times 100 = 116700$$

Since $\sigma_b = \dfrac{200}{5} = 40$

and $\sigma_e = 1200$

then, as $\sigma_e : \sigma_b = n(h - a - x) : x$

$$1200 : 40 = 15(h - a - x) : x$$

$$h - a = 3x$$

Inserting these in Equation 5 * we have

$$1200 = \frac{M}{\frac{5}{3}x\left(3x - \frac{x}{3}\right)}$$

$$x^2 = \frac{116700}{5333} = 21{\cdot}8826$$

$$x = 4{\cdot}68 \text{ cm.}$$

$$h - a = 3 \times 4{\cdot}68 = 14{\cdot}04$$

thus $h = 15{\cdot}54$ cm.

$$f_e = \frac{5}{3}x = 7{\cdot}8 \text{ sq. cm.}$$

Ten round steel rods of 10 mm. diameter, having an area of 7·85 sq. cm., will suffice per metre width of floor.

**3.** A T-beam of the dimensions indicated in the sketch, and being 10 metres long with a clear span of 9·6 metres carries a load of 500 kg. per sq. metre in an office. The reinforcement consists of 8 round steel bars of 2·2 cm. diameter,

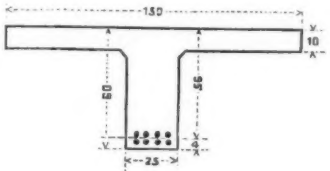


FIG. 4.

having a combined cross-sectional area of 30·4 sq. cm. It is required to find the maximum stresses in the steel and in the concrete.

* And finding $f_e$ from Eq. I.

$$\frac{100x^2}{2} = 15f_e\,(2x)$$

$$50x^2 = 30f_e\,x$$

$$\frac{5}{3}x = f_e$$

The dead load is thus made up: The weight of the T-beam is:

| | |
|---|---|
| $(1{\cdot}5 \times 0{\cdot}10 + 0{\cdot}5 \times 0{\cdot}25) \times 2400 =$ | 660 kg. |
| Weight of 6 cm. layer of rolled clinker | 36 |
| " " 2 " cement floor | 40 |
| " " flooring | 14 |
| for 1 sq. metre | 90 kg. |
| Or for 1·5 sq. metre = $1{\cdot}5 \times 90$ | 135 " |
| Live load | 500 " |
| Total | 1295 |

or, roughly, 1300 kg. for 1 metre length of beam.

Then

$$M = \frac{1300 \times 10^2 \times 100}{8} = 1625000$$

$$x = \frac{56 \times 15 \times 30{\cdot}4 + \frac{150 \times 10^2}{2}}{150 \times 10 + 15 \times 30{\cdot}4} = 16{\cdot}88 \text{ cm.}$$

$$y = 16{\cdot}88 - 5 + \frac{10^2}{6(33{\cdot}76 - 10)} = 12{\cdot}58 \text{ cm.}$$

$$\sigma_c = \frac{1625000}{30{\cdot}4 \times 51{\cdot}7} = 1034 \text{ kg. per sq. cm.}$$

$$\sigma_b = 1034 \times \frac{16{\cdot}88}{15 \times 39{\cdot}12} = \text{about } 30 \text{ kg. per sq. cm.}$$

The transverse force at the supports is

$$V = \frac{9{\cdot}6 \times 1300}{2} = 6240 \text{ kg.}$$

The shearing stress in the concrete is therefore

$$\tau_a = \frac{V}{b_1 (h - a - x + y)} = \frac{6240}{25(56 - 16{\cdot}88 + 12{\cdot}58)}$$

$$= \text{(roughly) } 5 \text{ kg. per sq. cm.}$$

The permissible value of the shearing stress is therefore somewhat exceeded. It is advisable to bend the ends of the four upper steel rods upwards. The point at which the bending should commence is given by the condition that $V_1$ should there be only $\frac{6240 \times 4{\cdot}5}{5} = 5616$ kg. This is fulfilled when $x = \frac{6240 - 5610}{1300} = \text{about } 0{\cdot}5$ m.

The adhesive stress on the four lower rods amounts to

$$\tau_1 = \frac{25 \times 5}{4 \cdot 3{\cdot}14 \times 2{\cdot}2} = 4{\cdot}5 \text{ kg. per sq. cm.}$$

**4.** A continuous T-beam of the section shown below, and on four supports, has to carry 500 kg. per sq. metre in

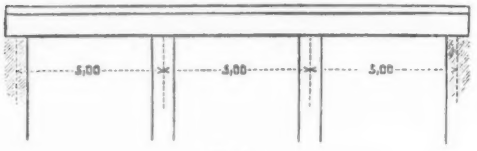


FIG. 5.

a warehouse. To determine the maximum stresses arising in the concrete and the iron.

The dead load for 1 metre length of beam is

| | |
|---|---|
| $(1{\cdot}50 \times 0{\cdot}10 + 0{\cdot}30 \times 0{\cdot}25)\ 2400 . . . =$ | 540 kg. |
| and the remaining load, as in the last example, = | 135 " |
| Total | 675 kg. |

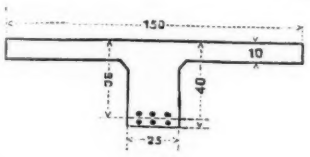


FIG. 6.

The moments are:

(*a*) At $0{\cdot}4l$ of the first span:

$$M_g = + 0{\cdot}08 \times 675 \times 5^2 \times 100 = + 134800$$
$$- M_p = - 0{\cdot}02 \times 500 \times 5^2 \times 100 = - 25000$$
$$+ M_p = + 0{\cdot}10 \times 500 \times 5^2 \times 100 = + 125000$$
$$\text{therefore } M_{\max.} = + 259800;$$

(*b*) Over the centre support:

$$M_g = - 0{\cdot}10 \times 675 \times 5^2 \times 100 = - 168750$$
$$- M_p = - 0{\cdot}11667 \times 500 \times 5^2 \times 100 = - 145838$$
$$+ M_p = + 0{\cdot}11667 \times 500 \times 5^2 \times 100 = + 20838$$
$$\text{therefore } M_{\max.} = - 314588;$$

(*c*) In the centre span:

$$M_g = + 0{\cdot}025 \times 675 \times 5^2 \times 100 = + 42188$$
$$- M_p = - 0{\cdot}05 \times 500 \times 5^2 \times 100 = - 62500$$
$$+ M_p = + 0{\cdot}075 \times 500 \times 5^2 \times 100 = + 93750$$
$$\text{therefore } + M_{\max.} = + 135938$$
$$- M_{\max.} = - 20312$$

The stresses are therefore:

(*a*) At $0{\cdot}4l$ of the first span:

The reinforcement consists of six round bars of 11 mm. diameter and 7·6 sq. cm. combined sectional area, 4 cm. above the lower surface.

Since the neutral axis falls in the flange, its position is found by Equation (2).

$$x = \frac{15 \times 7{\cdot}6}{150}\left[\sqrt{1 + \frac{2 \times 150 \times 36}{15 \times 7{\cdot}6}} - 1\right] = 6{\cdot}69 \text{ cm.}$$

Equations (4) and (5) then give:

$$\sigma_b = \frac{2 \times 259800}{150 \times 6{\cdot}69 \times 33{\cdot}77} = 15{\cdot}3 \text{ kg. per sq. cm.}$$

$$\sigma_e = \frac{259800}{7{\cdot}6 \times 33{\cdot}77} = 1011 \text{ kg. per sq. cm.}$$

(*b*) Over the centre support:

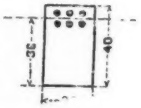


FIG. 7.

Since the concrete is to take up no tensile stresses, only the web with the reinforcement at the top has to be considered for the negative moment at the support. The position of the neutral axis is again found from Equation (2):

$$x = \frac{15 \times 7{\cdot}6}{25}\left[\sqrt{1 + \frac{2 \times 25 \times 36}{15 \times 7{\cdot}6}} - 1\right] = 14{\cdot}1 \text{ cm.}$$

$$\sigma_b = \frac{2 \times 314588}{25 \times 14{\cdot}1 \times 31{\cdot}3} = 57 \text{ kg. per sq. cm.}$$

$$\sigma_e = \frac{314588}{7{\cdot}6 \times 31{\cdot}3} = 1322 \text{ kg. per sq. cm.}$$

These stresses exceed the permissible values; they may be reduced by increasing the reinforcement. If two more steel rods of the same diameter be added, the stress in the concrete becomes 52 kg. and the stress in the steel 1072 kg. per sq. cm.

(*c*) In the centre span:

The $+ M_{max.} = 135938$ is considerably less than at $0{\cdot}4l$ of the first span. Three round steel rods of the tota cross-sectional area 3·8 sq. cm. are sufficient. Then

$$x = \frac{15 \times 3{\cdot}8}{150}\left[\sqrt{1 + \frac{300 \times 36}{15 \times 3{\cdot}8}} - 1\right] = 4{\cdot}86 \text{ cm.}$$

$$\sigma_b = \frac{2 \times 135938}{150 \times 4{\cdot}86 \times 34{\cdot}38} = 11 \text{ kg. per sq. cm.}$$

$$\sigma_e = \frac{135938}{3{\cdot}8 \times 34{\cdot}38} = 1046 \text{ kg. per sq. cm.}$$

For $- M_{max.} = - 20312$ it is sufficient to lay a wire of 1·13 sq. cm. section in the upper portion. Then

$$x = \frac{15 \times 1{\cdot}13}{25}\left[\sqrt{1 + \frac{2 \times 25 \times 36}{15 \times 1{\cdot}13}} - 1\right] = 6{\cdot}33 \text{ cm.}$$

FIG. 8.

$$\sigma_b = \frac{2 \times 20312}{25 \times 6{\cdot}33 \times 33{\cdot}89} = 8 \text{ kg. per sq. cm.}$$

$$\sigma_e = \frac{20312}{1{\cdot}13 \times 33{\cdot}89} = 530 \text{ kg. per sq. cm.}$$

**5.** A reinforced-concrete column 30 × 30 cm., with four steel rods of total cross-sectional area 16 sq. cm., is concentrically loaded with 30,000 kg. To determine the stresses arising in the concrete and steel.

$$30000 = \sigma_b(30 \times 30 + 15 \times 16)$$

$$\sigma_b = \frac{30000}{1140} = 26{\cdot}3 \text{ kg. per sq. cm.}$$

$$\sigma_e = 15 \times 26{\cdot}3 = 395 \text{ kg. per sq. cm.}$$

**6.** The same column is to be calculated for flexure, its height being 4 metres.

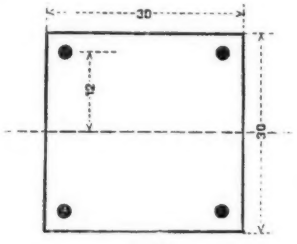

FIG. 9.

In Euler's formula

$$P = \frac{\pi^2 \cdot E \cdot J}{s \cdot l^2}$$

$$E = \frac{2100000}{15} = 140000$$

for concrete, and $s$ = the factor of safety = 10.

$$J = \frac{30^4}{12} + 15 \times 4 \times 4{\cdot}00 \times 12^2 = 102060$$

thus $$P = \frac{10 \times 140000 \times 102060}{10 \times 160000} = 89303 \text{ kg.}$$

Since $P$ is, as stated in the preceding example, only 30,000 kg., there is no danger of flexure in the concrete. In order that there should be no flexure in the steel:

$$\frac{\pi^2 \cdot E \cdot J}{5l^2} = F \cdot k$$

The stress $k$ in the steel was found above to be 3·5 kg. per sq. cm. Since for round bars

$$F = \frac{\pi d^2}{4} \text{ and } J = \frac{\pi d^4}{64}$$

so that $$\frac{J}{F} = \frac{d^2}{16}$$

the permissible length of rod subject to bending is

$$l = d\sqrt{\frac{10 \times 2100000}{80 \times 395}} = 25{\cdot}8d$$

Therefore to avoid flexure in the steel rods, they must be tied together by transverse pieces at intervals of $25{\cdot}8 \times 2{\cdot}26 = 58$ cm.

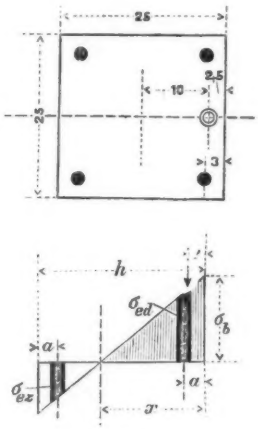

FIG. 10.

**7.** A reinforced concrete column of 25 × 25 cm. section with four steel rods of 2 cm. diameter is loaded eccentrically with 5000 kg. at a point 10 cm. from the centre. To determine the stresses arising in the concrete of the steel.

The two following relations are available for the solution of the problem:

(1) The sum of the external and internal forces must be zero. $\Sigma V = 0$.

(2) The sum of the statical moments of the forces acting on a section must be zero. $\Sigma$ Mom. $= 0$.

There is the further condition that the stresses are proportional to the distances from the neutral axis multiplied by the modulus of elasticity, thus

$$\sigma_b : \sigma_{ed} = x : n\,(x - a)$$

$$\sigma_b : \sigma_{ez} = x : n\,(h - a - x)$$

From condition (1) it follows that

$$(a) \qquad P = \frac{bx}{2}\sigma_b + nf_e\sigma_b\left(\frac{x-a}{x} - \frac{h-a-x}{x}\right)$$

$$= \sigma_b\left[\frac{bx}{2} + \frac{nf_e}{x}(2x - h)\right]$$

$$(b) \qquad P(x-e) = \sigma_b\frac{x^2b}{3} + nf_e\sigma_b\left[\frac{(x-a)^2}{x} + \frac{(h-a-x)^2}{x}\right]$$

$$= \sigma^1\left[\frac{bx^2}{3} + \frac{nf_e}{x}(2x^2 - 2hx + 2a^2 - h^2 - 2ah)\right]$$

Writing the two values of $\sigma_b$ obtained from these two equations as equal, we have

$$\frac{b}{6nf_e}x^3 - \frac{b\,.\,e}{2nf_e}x^2 - (2e - h)x = 2a^2 + h^2 - (2a + e)h$$

or, inserting the values $b = 25$; $n = 15$; $f_e = 6{\cdot}28$; $e = 2{\cdot}5$; $h = 25$; $a = 3$:

$$\frac{25}{6 \times 15 \times 6{\cdot}28}x^3 - \frac{25 \times 2{\cdot}5}{2 \times 15 \times 6{\cdot}28}x^2 + 20\,.\,x$$

$$= 2 \times 3^2 + 25^2 - 8{\cdot}5 \times 25$$

$$x^3 - 7{\cdot}5x^2 + 452{\cdot}16x = 9734$$

The solution is best obtained by trial, which gives with sufficient accuracy: $x = 16{\cdot}3$ cm.

Then, by means of Equation $(a)$:

$$5000 = \sigma_b\left(\frac{25 \cdot 16{\cdot}3}{2} + \frac{15 \times 6{\cdot}28}{16{\cdot}3} \times 7{\cdot}6\right)$$

$$\sigma_b = 20{\cdot}2 \text{ kg. per sq. cm.}$$

Then $\sigma_{eb} = \dfrac{15 \times 13{\cdot}3 \times 20{\cdot}2}{16{\cdot}3} \times 249$ kg. per sq. cm.

$$\sigma_{eb} = 249\,\frac{5\,7}{13{\cdot}3} = 107 \text{ kg. per sq. cm.}$$

*Berlin: 16th April* 1904.

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9, CONDUIT STREET, LONDON, W., *25th Nov.* 1905.

## CHRONICLE.

### Seventh International Congress of Architects 1906.

The following additions have been made to the list of Hon. Vice-Presidents of the Congress since the last publication:—

His Grace the Duke of Northumberland.
His Grace the Duke of Argyll.
The Right Hon. the Earl of Wemyss and March.
The Right Hon. the Lord Mayor of London.

The Executive Committee have the pleasure to announce that the Lord Mayor has very kindly signified his intention of entertaining the Congress (to the extent of 1,000 invitations) at a Conversazione at the Mansion House on the evening of Tuesday, 17th July 1906.

### Foundations of the Campanile of St. Mark's, Venice.

Mr. Horatio F. Brown, in a communication to *The Times* of the 16th inst., gives an interesting account of the works for the foundations of the new Campanile, which are now rapidly approaching completion. It is expected that the shaft will be begun next January, and, as the foundation works will be hidden from view when the pavement of the Piazza is replaced, the details given by Mr. Brown will serve as a useful record of what has been done. Mr. Brown, prefacing his description with some interesting notes as to the character of the subsoil upon which these foundations rest, and also as to the construction of the old foundations themselves, says:—

The whole city of Venice is carried on a thick cushion, or bed, of compact clay, into which the foundation piles are driven. This cushion rests in its turn on a deep stratum of watery sand. It is essential, in building, that the clay stratum should not be pierced, otherwise a geyser of water and sand is at once thrown up, and the pile loses its carrying power. This clay bed varies in thickness from about 18 feet to 24 feet in different parts of the town; it also varies in consistency—at the island of "Dorso duro," or "Hard Back," it is, as the name implies, very firm; so, too, at the point where the Campanile stood. Borings in the clay stratum have disclosed the fact that it is not homogeneous throughout; you come across layers of peat, or pockets of sand and mud—during the works on the foundations no water was tapped—and, as we shall

presently see, the existence of these flaws formed one of the difficulties in making the new foundations.

The old foundations consisted (1) of piles driven into the clay. These piles, at the single point where they were examined by Com. Boni, were found to be of white poplar, in very good preservation, and presenting a closely twisted fibre; but no doubt other woods were used, and there is no positive evidence as to the state of most of the piles. (2) On the top of the piles came a platform composed of two layers of oak beams, the lower layer running east and west, the upper layer crossing it from north to south. (3) On this platform were laid the foundations, properly so called: they consisted of seven courses of stone of various kinds and sizes, held together in some places by shallow-biting clamps, and generally by mortar, which on the surface and for some depth, especially below the sea level, had lost its cohesive power. (4) Above the foundations came the base of five courses of stone, set in stepwise. The height of the foundations from the platform to the crown of the base was 16 feet. When the weight of the tower was removed by its fall, the whole foundations rose up three centimètres ($1\frac{3}{10}$ inch), owing to the hydraulic upward thrust from the stratum of watery sand that underlies the clay. It was also found that a settlement of six inches had taken place at the north-east angle of the tower.

After the fall of the Campanile on July 14, 1902, and when it had been decided to rebuild it *dove era e come era*, the question arose as to what should be done with the original foundations. Though in no way responsible for the collapse of the tower, and not exactly in bad condition, they still presented some defects, and, above all, they were too narrow for so imposing a superstructure. As a matter of fact, the area of the foundations extended only four feet beyond the spring of the shaft. Indeed, the old foundations were never intended to carry a tower of such a height as the Campanile. It seems pretty clear from their relation to the remains of walls laid bare by the present works that the foundations were those, not of a Campanile, but of one of the defence towers that formed part of the fortifications of the Piazza. No modern architect would venture to go upon so restricted a base, even had its condition been quite satisfactory. The idea of building on the foundations as they were having been abandoned, the question arose whether they should be swept away to make room for entirely new work, or whether they should be preserved and enlarged so as to form the nucleus of the new foundations. Around this point a warm polemic was carried on. Certain authorities advanced arguments in favour of clearing away the old foundations. . . . On the other hand, a group of architects argued that, strictly speaking, what had carried the tower once should be able to carry it again; the old foundations were not responsible for the fall, and had suffered no damage from the collapse; it would therefore be amply sufficient to enlarge these foundations and to distribute the pressure over a wider area; there was, moreover, considerable danger in meddling with the foundation area in such a way as to disintegrate the clay. In support of this view came all the sentiment of the city. The decision was taken in this sense and was rendered irrevocable by the ceremony of laying the foundation-stone of the new Campanile in the centre of the old foundations, a ceremony performed with all pomp on April 25, 1903, by the Count of Turin, representing the King, by Pope Pius X., then Patriarch of Venice, and a host of international, national, and civic notables. But, as a matter of fact, the work now approaching completion is a compromise between the two conflicting views—a compromise imposed by the necessities of the case.

The question having been settled in favour of preserving and enlarging the old foundations, it was resolved, in order to secure homogeneity of construction, to proceed by the old method of piles, platform, foundations, and base. A ditch—about 16 feet drop—that is, down to the level of the pile-heads—was dug all round the old foundations to the width of about 12 feet, and carefully bratticed. Into the area thus laid bare they proceeded to drive 3,076 piles of larch-wood from Cadore, fresh cut so as to ensure the presence of abundant resin. The average diameter of the piles is $8\frac{1}{4}$ inches. Larch was preferred to oak, partly because experience has shown its admirable power of resisting decomposition when buried in the clay of the lagoon bed, partly because larch piles are straight; whereas oak is often bent and twisted, and would therefore have left frequent interstices. The piles are, on an average, 13 feet long. They were driven home to almost absolute resistance, that is to say, till they yielded only one millimètre to each blow from a weight of 570 lb. raised 4 feet 6 inches. They are calculated to have a carrying power of 30 tons each, giving a total carrying power of 90,000 tons about; the weight of the tower they are to support being estimated, allowing for hollow space, at 20,000 tons. At the angles the piles are in contact with each other; elsewhere they average twelve to the square mètre; the total enlargement of the foundation area amounting to 240 square mètres. While the work of driving the piles was in progress a difficulty manifested itself at the weak north-east angle—the angle that showed a settlement of 6 inches—the piles ran into a pocket of sand, and this sandy stratum was found to extend along the northern face of the foundations up to the north-west angle. The difficulty was overcome by driving thinner and rather longer piles in perfect contact with each other, until they reached the lower clay bed of the pocket. The settlement of the north-east angle was rectified by leaving the piles 8 inches higher at this point. The driving of these 3,076 piles was a slow process. It was carried on by the primitive method of hand-rope and pulley and weight; 11 ropes, or *campanelle*, and 11 hands to each pile-driver. Day after day all through the summer, from behind the palisade that hid the works, came the long, monotonous drone of the foreman giving the time to his hands in one of those all but immemorial chants to which the foundation piles of Venice have always been driven home. . . .

At length on October 8, 1904, the initial step of pile-driving was completed; and having now reached the level of the old platform the question of bonding the new work into the old came up for consideration. The new platform had to be superimposed upon the old if it was to catch and distribute the pressure of the tower. This led to the first attack on the old foundations. They were cut into to the depth of 8 feet all round and the new platform in its upper layer has been laid on the top of the old; a union which is neither complete nor quite satisfactory. The new platform, like the old, is made of two layers of oak beams, fresh cut in the forest of Montello. The lower layer runs parallel to the sides of the foundations, the upper is laid across, but at each angle there is a third layer, placed in the form of a fan of seven sticks, an ingenious device by which the pressure at the angles is distributed over a wide area. The layers are fastened together by wooden pins of that hard material dog-wood (*Corniolo cornus*) and the interstices filled in with cement and chips of the porous Monselice stone.

The question of bonding the platform has virtually decided the fate of the old foundations, for the incision of 8 feet all round means $19\frac{1}{2}$ feet of new foundations in every direction, and leaves only 200 cubic mètres of the old foundations as a mere nucleus in the centre of the new tower.

On the top of the new platform come the new foundations, formed of massive blocks of Istrian stone, cut in parallelopipeds and carefully cemented together. They are in 11 courses, stepped in from the external limit of the new foundations. Istrian stone was selected, rather than Euganean, on account of its compacter grain, which resembles that of marble. These blocks are bonded into

the old foundations to the depth of 6 feet 6 inches, the largest blocks being 9 feet 9 inches in length and 4 feet 7 inches in width; so that, as a matter of fact, the new Campanile will rest almost entirely on new foundations and a new platform, while its weight will be borne partly by new and partly by old piles. The method adopted for conveying these great blocks was of the most primitive kind; the method used, no doubt, by the builders of the original foundations: they were slowly and laboriously hauled by hand, with wooden rollers and ropes, up the length of the Piazzetta from the mole where the barges were moored.

But whatever the method the whole work looks massive and imposing, sufficient even to exaggeration. The cost down to the close of 1904 has been £4,623, so that when the foundations are finished the total expense will probably fall well within the £8,000 estimated for their construction.

### Mr. William Glover's Benefactions.

Mention was made in the last number of the JOURNAL of Mr. Wm. Glover's gift of £500 to the Corporation of Newcastle to celebrate the visit of the Institute to Newcastle-on-Tyne, the money to be held in trust and the interest applied to the purchase of works of art by local artists for the Laing Art Gallery. In sending the money to the Mayor of Newcastle Mr. Glover added another £300—making £800 in all—for the same object, "in memory," to quote his letter, "of my valued and esteemed clients in the three counties." By "local artists" are to be understood those of Newcastle, Northumberland, and Durham.

### London Building Acts 1894–1905.

Mr. Edward Stanford will publish early in December a revised and enlarged edition of Mr. Bernard Dicksee's *London Building Acts* 1894–1905, which will contain the full text of the various Acts, including the Amendment Act of the present year. The notes and references to the decisions of the High Court have been considerably extended and brought up to the present date.

## ALLIED SOCIETIES.

### LEEDS AND YORKSHIRE ARCHITECTURAL SOCIETY.

The opening General Meeting was held at the Queen's Hotel, Leeds, on Thursday, 16th November, when an Address, of which the following are extracts, was delivered by the President, Mr. G. Bertram Bulmer [*F.*].

Colleagues, Ladies, and Gentlemen,—The wheel of time has made one more revolution, and I find myself addressing you again as President of this Society. My long connection with it—extending to nearly thirty years—will be evidence to you that I have had always a deep interest in your welfare, and can assure you that I shall continue to take an interest in your prosperity and progress, although the time has come when younger and more active spirits will have to take the helm and steer your barque upon its appointed course. I thank the Members of Council for their support in the past year, and I am looking forward to the assistance of the Vice-Presidents in holding the meetings of the coming session. During the year we have lost the services of Mr. R. P. Oglesby. You all know the usefulness of a Society like ours is largely affected by the ability and vigour which its Hon. Secretary brings to his task, and in losing Mr. Oglesby we have lost an official whose enthusiasm and devotion to his work attained a high pitch, and we offer the thanks of this Society to him and our best wishes for success in his new career. His duties have now passed into the hands of Mr. A. E. Kirk, and we welcome him as one who will vie with his predecessor in keeping this Society in the front rank of the R.I.B.A.'s Allied Societies. "We have got the men." I wish I could finish the quotation and say "we have got the money, too." The question of finance is becoming a very important one, as our treasury is much depleted by the undertakings of the last three years, and there is in front of us a large amount of work to do, and consequent expense if we continue to maintain our support to the Architects' Enrolment Bill and the Board of Education. Our members must consider the possibilities of the situation and endeavour to strengthen our financial position by every means in their power. "Heaven helps those who help themselves," and we must not rely on the purse of an Honorary Treasurer to meet our deficiencies. By observing strict economy during the coming year I have no doubt we shall have a balance on the right side; but we should much prefer to have an ample reserve to meet exceptional calls. I draw your attention to this matter in the hope that some special effort may be made, in which I shall be only too glad to bear my part. . . . . .

May I now say a few words to our practising members? I should like to remind them that the alliance of this Society with the Royal Institute of British Architects gives them a direct and important influence on the life of our central institution, and having as many as seventeen Allied Societies their united opinion must carry weight with the Institute Council. I would therefore ask you to do all in your power to strengthen our hands. There are many who continue to give us the support of their names and subscriptions, but never take any part in our deliberations, and whose advice would be very valuable to us. Also I should like to see the Society strengthened by the addition of more members throughout the county, so that even isolated practitioners through us would obtain a guiding hand in the control of our professional interests—a matter at the present juncture of paramount importance.

Our list of honorary members might also be enlarged with advantage. The hope of the archi-

tecture of the future is largely dependent on the interest the public take in it, and if we can enlist the support of men of light and leading outside our profession—men who are largely concerned in promoting civic and private undertakings—I feel sure that nothing but good would result. To those who have supported us, in some cases for a long period, we owe our thanks. . . . . .

I am glad to say that the general business of the Society pursues the even tenor of its way. Our library, safely housed in the premises of the Leeds Free Lending Library, remains a useful adjunct of our institution. The classes, held in our own rooms and the premises of the Leeds Institute, continue to do good work, and we contemplate some extensions in this direction to meet the requirements of day pupils, and the curriculum may need some further adjustment to fall in line as far as possible with the views of the R.I.B.A. Board of Education. Our lecture list is an excellent one, and we hope that the goodness of the lecturers in coming such long distances to aid and assist us will be repaid by an adequate attendance of all classes of members and their friends, who can be introduced, by permission, to the sessional lectures.

I have touched lightly on various matters pertaining to our Society and its work. I propose now to deal with some questions which affect us in our relationship with the R.I.B.A. The most important of these is the movement in favour of registration, and I will briefly outline the steps which have been taken in that direction.

In January 1904 the Institute Council, which had been elected to support the movement, appointed a Registration Committee consisting of its own members and representatives of the Allied Societies. They appointed a Sub-Committee to formulate a scheme for the compulsory training, education, examination, and statutory qualification of architects. This Committee considered that the only way to obtain the above objects was by means of Parliamentary powers to prevent any person using the title "architect" who had not passed qualifying examinations such as are now required, or will be at the end of 1906, to obtain admission to the Institute. The Committee met monthly and held morning and afternoon sittings, with the result that a Bill entitled "A Bill to secure the Enrolment of Architects" was drafted, with the aid of the Institute solicitors and the eminent counsel, Mr. Cripps, K.C., and Mr. Clode. At a Council Meeting held in June 1905 this Bill was adopted and ordered to be circulated, along with the Committee's Report, to all members of the Institute, and the complete text of the Bill will be found in the Institute JOURNAL (No. 17) for 22nd July 1905, to which I refer my hearers. The new Council, recently elected, does not contain the *personnel* which was so active in promoting the Bill, and it remains to be seen what steps will be taken to utilise the weapon forged with such labour and assiduity by the Registration Sub-Committee.

The matter will not be allowed to rest, and we hope to see the Bill introduced into Parliament, supported by the Institute, its Allied Societies, and the profession generally. The feeling in favour of the Bill is, I believe, rapidly extending, and if the Institute is to represent the profession it must sooner or later carry this movement to a successful issue. The President and Council who perform this good work will earn the gratitude of the public and the profession, and will lay the foundations of the Institute for all time.

Another question in which our interests are closely interwoven with the Institute is the Education question, and it is a matter of some difficulty. Many of the provincial Societies are each in their own way grappling with it; but it has been thought that the various systems should be co-ordinated, and a uniform system of education established. With this object in view a Board of Architectural Education was constituted by the Institute Council in May 1904, consisting of certain members of the Institute, two representatives of the Architectural Association, and a body of advisory members representing the Universities and other educational bodies, and including the Architectural Schools of Liverpool, Manchester, Leeds, Birmingham, Edinburgh, Dublin, and Cardiff.

The Board has drawn up a curriculum, which it recommends for general adoption: viz. a four years' course, of which the first half shall be spent in the schools and the remaining two in an architect's office, school training to be continued through the second term—the Board to maintain a supervision over the pupils during the whole period. An excellent system, but I cannot at present see how it is to be carried into execution. The equipment of schools or studios would be an expensive matter, and even the large towns would have to look to the Institute for financial assistance to develop their existing schools on these lines, and at the present time many pupils go into an architect's office who could not afford to leave home and reside in the great centres and pay heavy school fees, in addition to the premiums they pay to enter an architect's office. The whole subject bristles with difficulties, so far, at any rate, as the provinces are concerned, and must receive the earnest consideration of the provincial Societies if the scheme is to be successfully carried into effect.

There is yet another item to which I should like to draw your attention, "The Conduct of Competitions." Nearly every architect has experience of the worry and unnecessary expense and trouble attending these transactions, and much has been done of late years to mitigate the evils. Opinion seems yet to be considerably divided on many points, and, although the employment of a professional Assessor is becoming daily more frequent, to the advantage of the public and the profession, the mode of selecting Assessors and the method and rules by which they regulate their action have not

given entire satisfaction, and call for amendment. To my mind we should endeavour to minimise the evils by declining competitions unless the commission to be earned is of a certain amount, and Assessors should do all in their power to reduce the cost of preparing designs by adopting a small scale, and permitting work drawn in pencil, and limiting the number of drawings required to a minimum.

It is a great step forward to find that promoters are so willing to take the advice of the Institute in organising their competitions, and with such an opportunity the Council should spare no effort to see that the interests of architects are thoroughly safeguarded. To the Council of the Institute we must look as the champion of this cause.

Now let me turn from the details which so intimately concern us and give some thought to the amenities of the city in which we live. As artists we desire to see it comely in form and colour; as citizens to find it sweet and sanitary, free from all unsightly embellishments, provided with open spaces for light and air, and wide streets for the circulation of traffic. For some years these principles have been recognised by our authorities, and praiseworthy effort made in all these directions. Why then do we nullify our efforts by permitting so much that is opposed to them? Perhaps the greatest destroyer of our architectural efforts is the advertising fiend, whose emissaries are overrunning every corner of the city and suburbs. No place is safe from their encroachments. The main streets of the city, the highways which lead to and from it, the country lane—once sacred to rural beauty—are alike desecrated by the advertisement hoarding and the flaring lettering of the self-seeking advertiser. This growing nuisance must be controlled, and town and country authorities have more power to deal with transgressors. Owners of property also could assist by prohibiting their tenants from defacing the buildings with signboards and prominent lettering, confining all privileges in this direction within strict limits. Half a century has passed away since the French imposed restrictions. We have a national Society dealing with the question, which was formed in 1893, and in the spring of this year the Advertisement Regulation Bill passed its second reading in the House of Lords; but the evil is so widespread that it will be necessary to form an overwhelming public opinion which will perceive the folly of spending money and effort in beautifying our cities and buildings, and mutilating the result with flaming advertisements. Yet another feature will have to be eliminated if we intend to promote the æsthetic treatment of our great thoroughfares—the standards and overhead wires in connection with our tramway system. It is to be desired that engineering skill will devise a method to bring this about. Another means of obtaining a clean and cheerful aspect for our streets is the use of cleansable material, such as hard bricks and terra-cotta. We have two samples in this city which periodically renew their pristine beauty, and will continue to do so for ages to come by the application of water supplied by a hose-pipe. Unfortunately terra-cotta lends itself so readily to the repetition of ornament that there is danger of making our designs too elaborate, and the multiplication of ornamental features makes the cleansing process more difficult. Therefore we should aim at plain wall-surfaces, with high-class decoration sparingly used.

At the risk of wearying you I will draw your attention to one more subject in this connection, and not by any means the least. Prevention, it is said, is better than cure, and to reduce the dirt and smoke created in our vast city is of paramount importance, and does not receive the consideration it deserves. In private dwellings much may be done to reduce the smoke nuisance by using fireplaces of the most approved design, and in business premises by circulating hot water for heating purposes from a boiler and furnace to which smoke-consuming appliances can be attached. The large manufacturing concerns are the great producers of smoke, and much is done doubtless to keep them within bounds; but I submit there is a field here for further effort on the part of designers of smoke-consuming apparatus, and the authorities whose duty it is to see them applied.

I thank you, gentlemen, for the attention you have given to my desultory remarks, and will conclude my address by supporting the appeal made by Mr. Belcher for further help for the Architects' Benevolent Society. We have arranged to give an annual subscription which I should like to see increased, and Mr. Sydney D. Kitson has kindly agreed to act as local Hon. Secretary. I trust that the Leeds and Yorkshire Architectural Society will earn distinction by doing all in its power to support this institution in its good work of aiding the sick and unfortunate members of our profession.

## MINUTES. II.

At the Second General Meeting (Ordinary) of the Session 1905–06, held Monday, 20th November 1905, at 8 p.m.—Present, Mr. John Belcher, A.R.A., *President*, in the Chair, 55 Fellows (including 14 members of the Council), 62 Associates (including 3 members of the Council), 2 Hon. Associates, and several visitors: the Minutes of the Meeting held 6th November 1905 [p. 20] were taken as read and signed as correct.

The following members attending for the first time since their election were formally admitted and signed the respective Registers: John Priestley Briggs and Brook Taylor Kitchin, *Fellows*; Kenneth Duncan Stewart Robinson and Charles Lovett Gill, *Associates*.

A Paper on Some American Methods of Erecting Buildings, by Mr. R. A. Dencll, having been read by the author and discussed, a vote of thanks was passed to him by acclamation.

The proceedings then closed, and the meeting separated at 10 p.m.